SCIENCE

FRIDAY, APRIL 30, 1915

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MSS. intended for publication and books, etc., intended for review should be sent to Professor J. McKeen Cattell, Garrison-on-Hudson, N. Y.

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE[1]

STANDARDS OF VENTILATION IN THE LIGHT OF RECENT RESEARCH

THE fact that the stagnant air of an occupied room becomes uncomfortable and makes those who are exposed to it listless and inert is a matter of common experience. When overcrowding in a close unventilated space reaches a certain point the results may even be fatal within a few hours, as in the Black Hole of Calcutta, the underground prison at Austerlitz and the hold of the ship Londonderry. Conversely the value of fresh air in the treatment of tuberculosis and other diseases is one of the fundamentals of medical and hygienic practise.

For the sanitarian it is necessary, however, to know something more than this general fact that bad air is bad. He must not only have some workable conception as to its operation, but also a more or less definite standard of permissible deviation from absolute purity.

In the earlier days of ventilation this was an easy task. It was natural to assume that the evil effects of the air of occupied rooms was due, either to lack of oxygen or excess of carbon dioxide, or to the presence of some specific organic poison of human origin—morbific matter or anthropotoxin, as this hypothetical substance was called. Of either of these changes the amount of carbon dioxide should serve as a fair measure, and a carbon dioxide standard was therefore confidently advanced by the older sanitarians as a practically all-suffi-

[1] Papers presented at a Symposium on Ventilation at the Philadelphia meeting.

cient measure of atmospheric vitiation. Even as late as 1910 in the excellent textbook of Hoffman and Raber one could read that carbon dioxide

> is constantly being diffused throughout the air of the room, thus rendering it unfit for use. If this carbonic acid gas could be dissociated from the rest of the air and expelled from the room without taking large quantities of otherwise pure air with it, the problem of the heating engineer would be simplified, but this can not be done.

Yet Pettenkofer as long ago as 1863 showed clearly that carbon dioxide in itself is quite without effect in the highest concentrations which it ever attains in occupied rooms, and during the last fifteen years the researches of Flügge, Haldane, Hill, Benedict and other physiologists have rendered the older and more naïve view of the subject entirely untenable. Their studies indicate beyond any reasonable doubt that the more obvious effects experienced in a badly ventilated room are due to the heat and moisture produced by the bodies of the occupants, rather than to the carbon dioxide or other substances given off in their breath. Two fundamental experiments have been repeated again and again by these observers which alone would suffice to demonstrate, as Professor F. S. Lee has so well expressed it, that the problem of ventilation is not chemical, but physical—not respiratory, but cutaneous. These are, first, that subjects immured in close chambers, and exposed to the heat as well as the chemical products formed therein, are not at all relieved by breathing pure outdoor air through a tube; and, second, that they are completely relieved by keeping the chamber artificially cool without changing the air at all, and are relieved to a considerable extent by the mere cooling effect of an electric fan.

When the New York State Commission on Ventilation began its work last year it seemed that in spite of the establishment of these broad principles the subject deserved further detailed study at its hands, particularly in regard to possible undetected effects of chemical impurities and in regard to the harmful influence of moderately but not excessively high temperatures which have received but little attention in earlier researches.

The work of the N. Y. State Commission was made possible by a generous gift of Mrs. Elizabeth Milbank Anderson through the N. Y. Association for Improving the Condition of the Poor, and the members of the commission are Mr. D. D. Kimball, Professor F. S. Lee, Dr. J. A. Miller, Professor E. B. Phelps, Professor E. L. Thorndike and the writer. The experiments so far conducted have been carried out in two experimental rooms placed at our disposal by the trustees of the College of the City of New York and now equipped so that the atmospheric conditions in one room can be very closely controlled by apparatus located in the other. In the observation room over one hundred different subjects in groups of four have been exposed for periods of from three and a half to eight hours a day for from one to eight weeks in each series of experiments, to known conditions of temperature and humidity and atmospheric vitiation and their physiological and psychological reactions and mental and physical efficiency observed and measured by the most exhaustive methods.

The results of our experiments to date have been presented before the American Public Health Association at its Jacksonville meeting and may be briefly summarized as follows:

Even quite extreme conditions of heat and humidity (86° with 80 per cent. relative humidity) had no measurable effect upon the rate of respiration; dead space in the lungs; acidosis of the blood; respira-

tory quotient; rate of digestion and rate of heat production (both measured by oxygen consumption); protein metabolism (measured by determinations of creatinine in the urine); or skin sensitivity.

On the other hand, the working of the circulatory and heat regulating machinery of the body was markedly influenced by even a slight increase in room temperature,

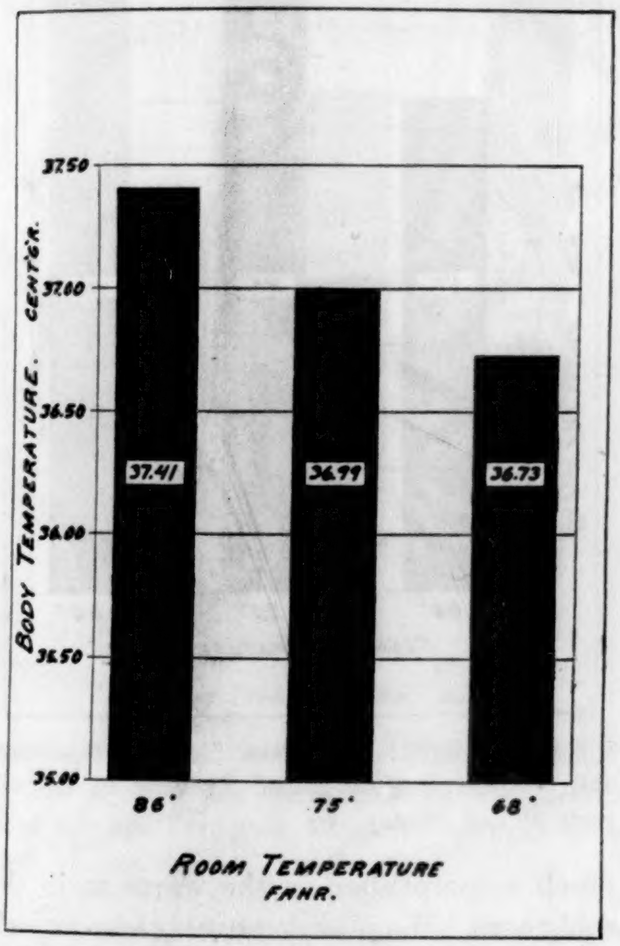

FIG. 1. Relation between Room Temperature and Average Rectal Temperature of all subjects at end of day.

as, for example, from 68° to 75° with 50 per cent. relative humidity in both cases. In a hot room (86°—80 per cent. relative humidity) the rectal body temperature usually rose during the period of observation; in a warm room (75°—50 per cent. relative humidity) it remained on the whole about constant; in a cool room (68°—50 per cent. relative humidity) it fell. The average body temperatures attained under these three room conditions were 37.41°, 36.99° and 36.73°, respectively. So the reclining heart rate rose in the hot room to a final average of 74 beats per minute and fell in the cool room to a final average of 66 beats (the warm condition not being comparable in this case). I use the terms hot, warm and cool throughout for the three temperatures and humidity combinations

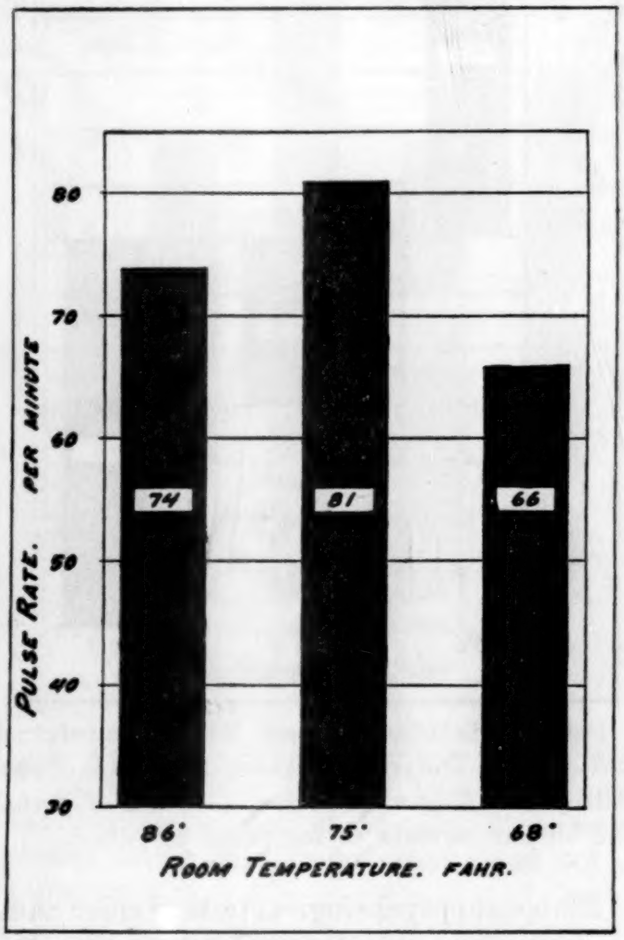

FIG. 2. Relation between Room Temperature and Average Reclining Pulse Rate of all subjects at end of day. (High value at 75° due to preceding physical work not duplicated at other temperatures.)

cited above. The increase of heart rate on passing from a reclining to a standing position became greater (by an average of 7 beats) during a sojourn in the hot room; while it became less by an average of 3 beats in the warm room and by an average of 7 beats in the cool room. The systolic blood pressure was slightly decreased in

the hot room (112 mm. against 116) and the Crampton value was markedly decreased, averaging 35 for the hot room, 45 for the warm room and 60 for the cool room.

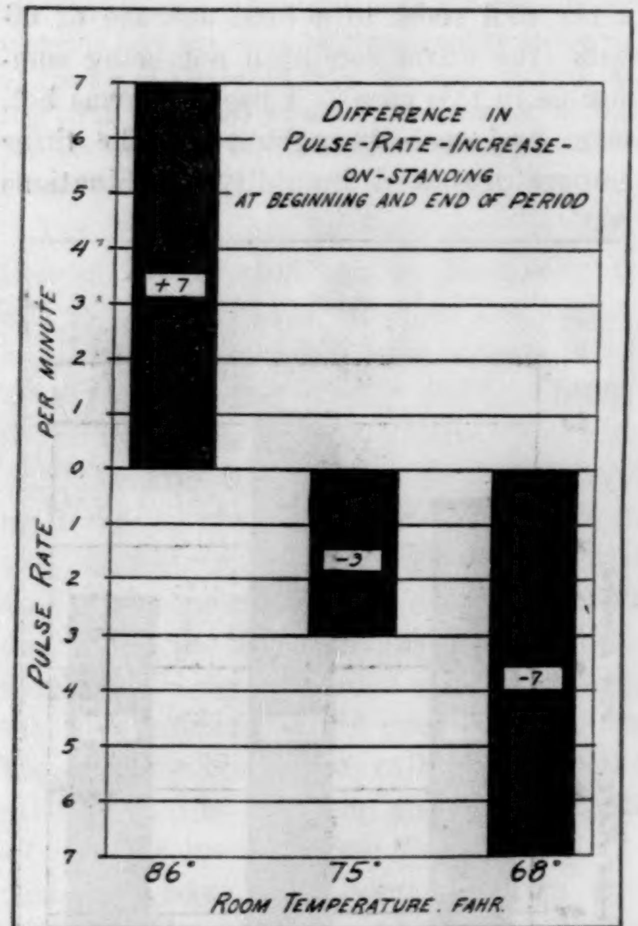

FIG. 3. Relation between Room Temperature and Average Difference between Increase-in-Pulse-Rate-on-Standing after reclining at end of period and similar increase at beginning of period.

Elaborate psychological tests of color naming, naming opposites, addition, cancellation, mental multiplication, typewriting and grading specimens of handwriting, rhymed couplets and prose compositions, all failed entirely to show any effect of even the severe 86°—80 per cent. relative humidity condition upon the power to do mental work under the pressure of a maximal efficiency test. Option tests of the inclination to do work, in which the subjects had the choice of doing mental multiplication or typewriting for pay, or of reading novels or doing nothing, showed a distinct lessening in the total amount of work done in the hot room while with male subjects whose votes as to comfort showed no preference for the 68° over the 75° condition there was as

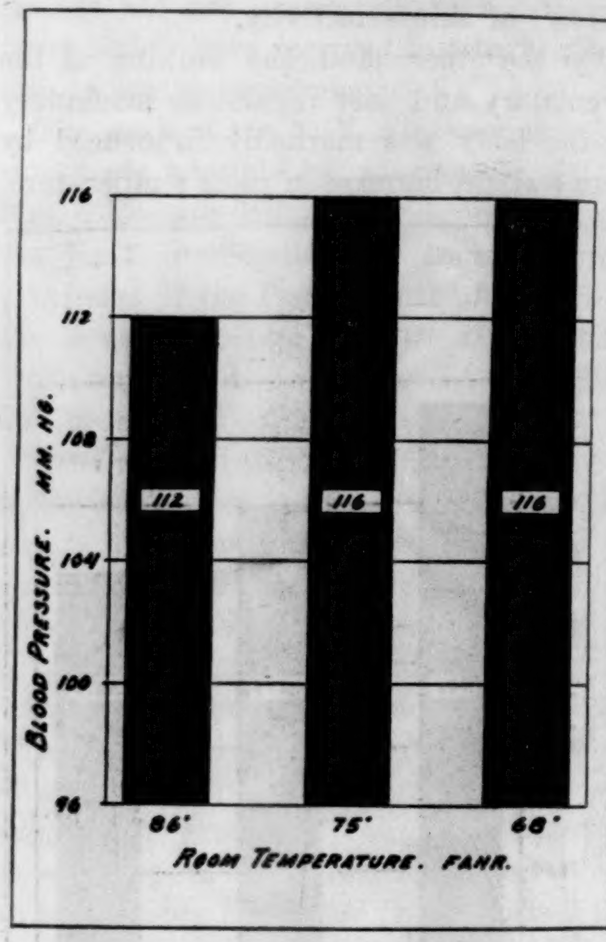

FIG. 4. Relation between Room Temperature and Average Systolic Blood Pressure of all subjects at end of day.

much accomplished in the warm as in the cool room. We plan to repeat these experiments with women subjects who may probably be more susceptible to slight degrees of overheating.

The results with physical work (lifting dumbbells and riding a stationary bicycle) were much more definite. Again maximum effort tests showed no appreciable influence of room temperature, but when the subjects had a choice they accomplished 15 per cent. less work at 75° and 37 per cent. less at 86° than at 68°. These conclusions are quite what one would expect. Under pressure efficient work can usually be accom-

plished even under unfavorable conditions, but as a matter of common experience we find that the children in overheated schoolrooms and the workers in overheated factories are listless and inactive.

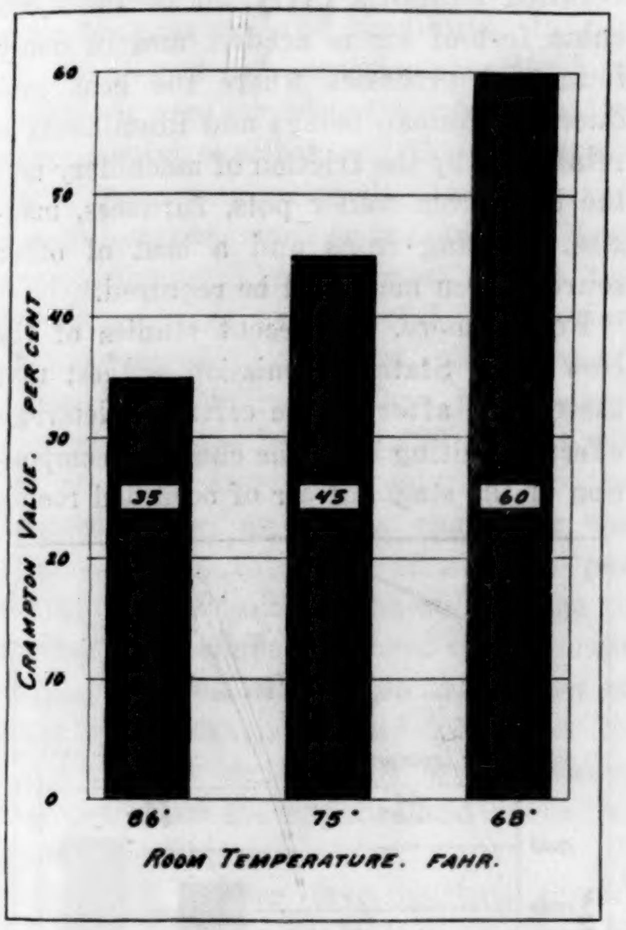

FIG. 5. Relation between Room Temperature and Average Crampton Value for all subjects at end of day.

Experiments are now under way in regard to the influence of overheated rooms upon susceptibility to respiratory disease which promise to confirm the observations of Leonard Hill as to the changes in the mucous membranes which follow exposure to hot and dry air, while we find that the resistance of animals to artificial infection is very definitely lowered by chill following exposure to a hot atmosphere.

As to the effect of stagnant breathed air, contaminated by a group of subjects so as to contain on an average from 20 to 60 parts of carbon dioxide per 10,000, our observations are entirely negative, so far as the physiological and psychological and efficiency tests above mentioned are concerned. So long as the room temperature was the same it seemed to make not the slightest

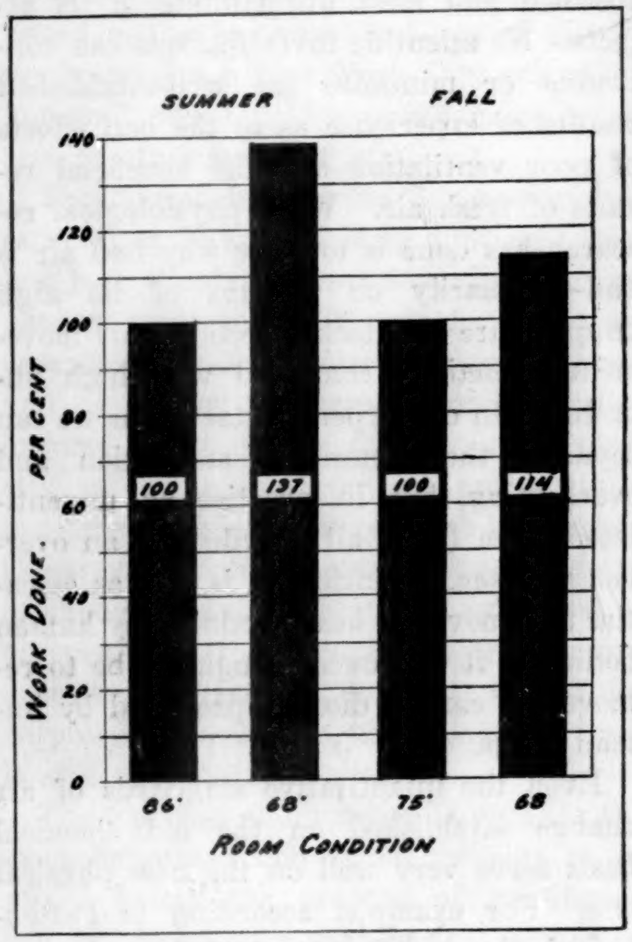

FIG. 6. Relation between Room Temperature and Average Amount of Physical Work accomplished during the day, in summer and fall experiments.

difference to our subjects whether the air in the chamber was stagnant or was renewed at the rate of 45 cubic feet per minute per capita—except in one particular respect to be discussed more fully below.

It is perhaps not unnatural that these results, like the similar results of earlier investigators, should be popularly misinterpreted as meaning that ventilation of any kind is a needless luxury. When the first progress report of the commission was discussed in a New York paper under the headline, "Commission put its O. K. on

Stagnant Air," the curator of a large college building at once called upon the chief of the investigating staff to ask if he would be justified in stopping his fans. Such a conclusion as this is, of course, quite unjustified and most unfortunate in its effects. No scientific investigations can contradict or minimize the well-established results of experience as to the bad effects of poor ventilation and the beneficial results of fresh air. What physiological research has done is to show why bad air is bad—primarily on account of its high temperature and lack of cooling air movement, sometimes combined with high humidity. In our experimental rooms we can separate the factors of stagnation and overheating, but in practise an unventilated room (if at all crowded) is an overheated room. Ventilation is just as essential to remove the heat produced by human bodies as it was once thought to be to remove the carbon dioxide produced by human lungs.

Even the quantitative standards of air change established on the old chemical basis serve very well on the new physical one. For example, according to Pettenkofer's classical figure, which is a very low one, an adult gives off 400 British thermal units per hour. Let us assume that this heat must be removed by air entering the room at 60° and leaving it not above 70°. One B. T. U. raises the temperature of about 50 cubic feet of air by 1°, or the temperature of 5.0 cubic feet of air from 60° to 70°. Hence our average adult producing 400 B. T. U. will require 2,000 cubic feet of air per hour at 60° to keep the surrounding temperature from rising. An ordinary gas burner produces 300 B. T. U. per candle-power hour; therefore each such burner requires 1,500 cubic feet of air per candle power. These calculations, of course, ignore direct heat loss through walls and ceiling which with a zero temperature outside may carry off the heat produced by 50 or 100 people. Ventilation provisions must, however, be based on the least, rather than on the most, favorable conditions. In crowded auditoria every bit of the 2,000 cubic feet of air is needed, and in many industrial processes where the heat produced by human beings and illuminants is reinforced by the friction of machinery and the heat from solder pots, furnaces, mangles, pressing irons and a host of other sources, even more will be required.

Furthermore, the recent studies of the New York State Commission suggest that there may, after all, be certain deleterious effects resulting from the chemical composition of the stagnant air of occupied rooms,

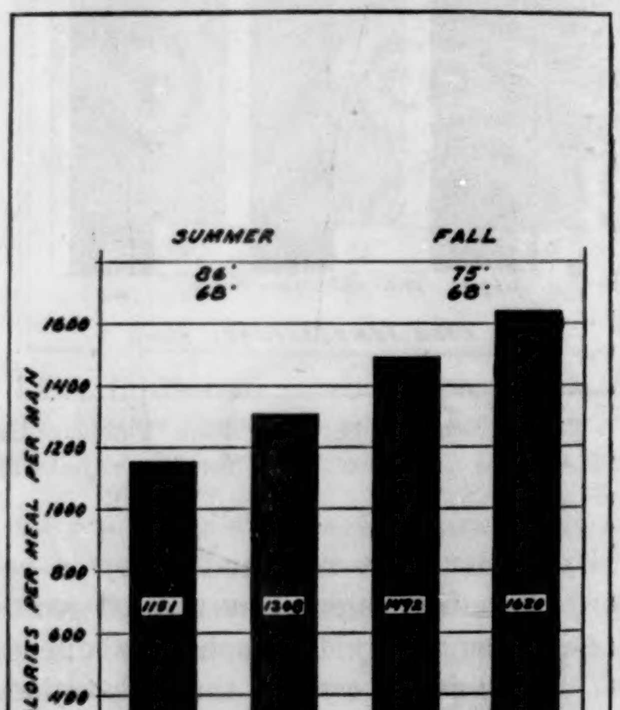

FIG. 7. Average Calorific Value of luncheons eaten with ample supply of fresh air and with no fresh air supply. In both summer and fall experiments the same conditions as to temperature and humidity prevailed through each series.

entirely aside from its temperature. As noted above, all the ordinary physiological and psychological tests failed to show any such effect; but in one particular we noted a difference in the behavior of the subjects exposed to stagnant and fresh air of the same temperature and humidity. In two of our series of experiments standard luncheons were served to the subjects in the experimental chamber and the amount on their plates was weighed. In one series the subjects consumed on the stagnant days an average of 1,151 calories and on the fresh-air days an average of 1,308 calories, an increase of 13 per cent. In a second series during colder weather, the average consumption was larger, 1,492 calories for the stagnant and 1,620 calories for the fresh-air days, an excess again for the fresh-air days, this time of about 9 per cent. The opinions of the subjects as to their comfort slightly favored the stagnant days, but it seems possible that odors of some sort, not consciously perceived by those exposed to them for several hours, may yet affect the appetite and hence the general health.

Even if further investigations should fail to confirm this result, it is my personal feeling that occupied rooms should be kept free from noticeable odors as a measure of public decency if not of public health. The cleanliness which results from the habit of bathing, except for the washing of the hands before eating, has, so far as I am aware, no important sanitary results. Just as the people who have been in a close room do not notice the odors which have accumulated during their occupancy, the person unaccustomed to bathing is unconscious of the effect produced, yet common decency rightly demands both bodily cleanliness and fresh air.

Recent research has, on the whole, strengthened rather than weakened the arguments for ventilation. It has shown, however, that the physical quality of the air as well as its amount must be considered, and that a room supplied with air at the room inlet which will explode a thermometer registering to 125° (which happened to the instrument of one of my investigators in a New York City school) is not well ventilated, however many cubic feet of air may enter it.

The thermometer is the first essential in estimating the success of ventilation. Temperature standards must come into general use and a rise above 70° must be recognized as a sign that discomfort is being produced and efficiency decreased and vitality lowered. The carbon dioxide standard is still of value, however, as ordinarily a measure of the air change which is required to carry off both heat and odors; and the mechanical standard of thirty cubic feet of air per minute per capita as the amount necessary to supply in some way if an occupied room is to remain cool and fresh is still of general application.

The question of humidity is perhaps the most important one which remains to be solved before the practise of ventilation can be placed on a sure basis. A lack of humidity, as Professor Phelps has pointed out, makes hot air feel cooler and cold air feel warmer. Extreme dryness per se, however, at high or moderate temperatures, is believed by many to be in itself harmful, conducing to nervousness and restlessness and producing injurious effects upon the membranes of the nose and throat. There is, unfortunately, no solid experimental evidence upon this point, and this is one of the most important subjects which the N. Y. State Commission hopes to be able to study during the coming year.

It is a foolish empiricism which maintains that outdoor air as Nature makes it is necessarily the final word in air con-

ditioning. The task of applied science is to find out the best elements in a natural environment and to select the good without the bad.

Only as we succeed by the application of the methods of research in disentangling and measuring the various factors involved in atmospheric influence shall we be able to establish sound standards for the practical art of ventilation.

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New York City

SOME ENGINEERING PROBLEMS IN VENTILATION

In the study of ventilation the engineering problems have not been overlooked. The criticisms directed against artificial ventilation have accomplished the double purpose of spurring to greater effort those who have been investigating the physiological problems relating to this subject and of causing the ventilating engineer to investigate the mechanical features of his work, with the intent of determining whether ventilation systems as installed meet all of the demands of good ventilation as now understood and whether they operate at a maximum of mechanical efficiency.

A careful review of the results in both fields is of surprising interest. The sanitarian formerly told us that carbon dioxide was a poison, that insufficient ventilation meant insufficient oxygen for breathing purposes and that we were endangered by "crowd poison" when in a mass of people. But little was said of temperature, less of humidity and nothing of air movement. We all believed that the chemistry of the air was vital.

The sanitarians, as a result of much experimentation, beginning about ten years ago, have proven to the satisfaction of all that there were other factors within the realm of ventilation of much greater importance than the chemistry of the air, notably its temperature, humidity and air movement, that is, the physical condition of the air.

The effect of excessive temperatures and humidities is especially well understood, as is the demand for constant air movement for the elimination of bodily heat and moisture. Less is scientifically known of the effect of cold and the effect of low humidities. The solution of these two problems is of vast importance.

Some there are who disregard altogether air quality, pinning their entire faith on proper temperature, humidity and air movement. Such a position is not justified by any reliable data now available. The cumulative effect of long exposures to stagnant air must be studied before safe conclusions may be drawn. Attention may be directed to the fact that in the experiments of the New York State Commission on Ventilation stagnant air decreased the appetite of the subjects 13 per cent. Is it not safe to assume that this is indicative of other, and possibly more serious, results. The report of Professor Winslow on the first year's work of the commission well states that this is "an observation which for the first time offers scientific evidence in favor of fresh air as compared with stagnant air of the same temperature and humidity." A final determination of the importance of air quality involves extended experimentation.

Window ventilation has been put forward as a panacea for all of ventilation's ills. But how little we scientifically know of its worth or its difficulties, especially those of air distribution, drafts, stagnant areas, temperature regulation, humidification, dust and economics.

But real advances have been made in solving the long-standing question of what constitutes good ventilation. The solution

of the remaining problems is but a matter of brief period. Coincidently, splendid advances have been made in working out the mechanical problems of ventilation. The details of the installation of the boiler plant have been refined with a resulting increase in the efficiency of operation. New methods of steam distribution, such as the vapor, modulating and vacuum systems, have produced added comfort and economics. Temperature control systems have been devised and perfected to a point of reliability and durability. The individual duct ventilating system, providing air in the volumes and of the exact temperature required by each individual room under varying weather and other conditions, has been developed. Greater attention is paid to the diffusion of the ventilating air. More attention is now paid to the character of the installation and the materials used therein. Also much emphasis is being placed upon the measure of intelligence exercised in the operation of the plant, upon which both efficiency and economy depend. More effort, however, still needs to be made in these last two directions. Noisy heating and ventilating plants may be considered a thing of the past, for noise is indicative only of lack of skill in design or installation.

Ten years ago the mechanical efficiency of the ventilating fan customarily used was about 45 per cent. Now the best type of fan (the multi-blade) has an efficiency of 65 per cent. This advancement results in the saving of more than 30 per cent. of the power expenditure for ventilation. The efficiency of the driving device has also been increased, although in a less degree.

Possibly the most interesting, important and valuable recent addition to the equipment of ventilating plants is that of the air washer. Reference to air washing is made by Dr. D. B. Reid in his book on "Ventilation" published in London in 1844 but it is really a product of the last ten years. Briefly it consists of a sheet-metal chamber in which the air is passed through a heavy mist and then through baffles or eliminator plates by which the air is so deflected that the entrained moisture is removed. The base of the washer constitutes a tank, into which the spray water falls and from which it is drawn by a centrifugal pump, usually motor driven. The pump forces the water through pipes and so-called nozzles which atomize the water in the spray chamber of the washer.

The manufacturers of these washers customarily guarantee the removal of 98 per cent. of the dust in the air. Practically all of the larger dust particles are removed but there is always a residue of fine dust which no washer will remove. In dry windy weather when there is a great deal of dust in the air, a large percentage of the dust is removed, but when there is very little dust in the air, as after a heavy rain, a small percentage of the dust is removed. Thus in Mr. M. C. Whipple's studies of the air washer it was found that the dust removal varied from 64 per cent. to 7 per cent. Certain dusts are not, to an appreciable extent, removed by the air washer. A standard method of testing air washers is needed and efforts are being made by the American Society of Heating and Ventilating Engineers to work out this problem.

The best results obtained in artificial humidification have been through the medium of the air washer. By the use of thermostatic devices an accurate control of the degree of humidification is obtained. The use of the evaporating pan containing a steam coil placed in the fresh-air chamber, the coil being under thermostatic control, also makes possible artificial humidification, but less satisfactorily.

The air washer may also be used for air

cooling. The evaporation of the water in the spray chamber will result in a lowering of the temperature of the air to the extent of 75 per cent. or more of the difference between the wet and dry bulb temperatures, often amounting to 10 to 15 degrees and sometimes to 18 to 20 degrees. This is due to the fact that water can not be evaporated without a supply of heat from some source, and in this case the heat is taken from the air. Considerable cooling can be done by the use of the same water recirculated by the pump and a greater degree of cooling may be accomplished by a continual supply of cold water. Purchased from the city mains this would be expensive, but if pumped from an artesian well the cost is small. Where a constant cooling effect is desired, independent of weather conditions, the use of a refrigerating plant in combination with the washer is necessary. The water tank is then increased in size and brine or ammonia coils, partially submerged and partially subjected to the falling spray, are installed. This is the most efficient method of positive artificial cooling, and is the most desirable method for ordinary purposes. Unfortunately it is expensive to install, involving approximately \$300 to \$600 per thousand cubic feet of air cooled. The cost of operation altogether depends upon the nature of the plant of which it is a part. If the plant is large, with exhaust steam to spare for use in an absorption refrigerating machine and the cooling water used in connection with the refrigerating plant may be used in the boilers and for domestic purposes in the building, the cost of operation is slight. Otherwise it may be roughly stated that the cost of cooling ten degrees during the summer is approximately equal to the cost of heating seventy degrees during the winter.

Cooling by evaporation of water alone has the disadvantage of increasing the humidity, which is usually considered objectionable. But there is some evidence that in hot weather the lower temperature with higher humidity is preferred by workers. Mr. J. I. Lyle quotes, among others, an engineer who has done a great deal of testing laboratory work, in which the conditions were most exacting. He writes:

> We can state that under the conditions shown by the readings below, the inside condition with a lower temperature, but a higher humidity, is more pleasant than the outside condition with higher temperature and lower humidity.

He illustrated by a comparison of outside conditions of 90 degrees dry bulb, 80 degrees wet bulb and 65 degrees relative humidity with inside conditions of 85 degrees dry bulb, 79 wet bulb and 77 per cent. relative humidity.

For ordinary ventilation work cooling at the expense of an increased humidity has been regarded as objectionable. It is said to produce a moist "clammy" feeling. Thus dehumidification becomes a part of artificial cooling, and the most expensive part, for the air must be cooled to that temperature at which saturated air contains the moisture necessary to give the desired relative humidity in the air when reheated to the ultimate temperature.

The use of the air washer has become almost indispensable in many industries, such as textile manufacturing, candy, macaroni, photographic and film making and in some processes of paper, tobacco, chemical, steel and plumbing fixture manufacturing.

Commercial considerations have done much to develop the use of the air washer in industrial fields. It is regrettable that humane considerations have done much less in this way in the general field of ventilation.

Possibly the most interesting study in the mechanics of ventilation is that of the

recirculation of the air used for ventilation. The New York State Commission on Ventilation, established through the generosity of Mrs. Elizabeth Milbank Anderson, has been actively interested in this work, and worthily so, for should it prove practical the cost of ventilating would be materially reduced. At one of the first meetings of the commission arrangements were made to carry on research work in this field. It was found that experiments along this line had been conducted by Dr. J. H. McCurdy, at the International Y. M. C. A. College Gymnasium, at Springfield, Mass., and at the Jackson School, Minneapolis, by Professor Frederic Bass. With the direction and support of the commission both of these experiments were continued under improved conditions.

In the former case use was made of the plant installed for ventilating the building, which was readily adaptable to the purpose.[1]

This system included motor-driven supply and exhaust fans, heaters and an air washer of 36,000 to 40,000 cubic feet per minute capacity, or over 300 cubic feet per minute per occupant. It is such a system as is usually used for ventilating such buildings, and not an experimental plant, except that the volume of air used was larger than usual. By the manipulation of dampers the air could be supplied entirely from out-of-doors air, the air could all be recirculated or part outdoor air and part recirculated air could be used. The air could be washed or not, as desired. Experiments were made under all of these conditions, the subjects being the college students at exercise in the gymnasium, usually about 70 in number.

The carbon dioxide content of the air, the humidity and the temperature were carefully studied. Also studies of the efficiency and results of air washing were very carefully made by Mr. M. C. Whipple, of Harvard University.

The conclusion was reached that there seemed to be no appreciable difference between washed recirculated air and outdoor air similarly treated so far as bodily comfort is concerned. Naturally the proportion of carbon dioxide is greater when using the recirculated air, but no significance is attached to this fact. Mr. Whipple concludes "that recirculation provided a plentiful supply of air with no apparent sacrifice of wholesome properties, and that it is a safer source of supply than outside unwashed air."

During the winter of 1913–14 further studies were made at Springfield under the direction of the Ventilation Commission, the results obtained from recirculated air being equally as satisfactory as those obtained from the use of outdoor air. Window ventilation failed to give satisfaction.

Odors were not noticeable to those occupying the room during the use of recirculated and washed air, although sometimes barely noticeable to one entering from out-of-doors.

Conclusions were based upon the results of physiological examinations and comfort votes of the students.

In the second case a special plant was installed for one room of the school building, the pupils in the room serving as subjects. The air was introduced into the room at the top of each desk through a 2-inch vertical riser from a duct below the floor, emerging through a funnel-shaped, nearly horizontal orifice, at a velocity which was barely perceptible at a distance of two feet from the opening.[2] Air was also introduced at the top of the blackboards at the ends of the room. The air was exhausted through fifteen 3-inch openings evenly

[1] Described by G. F. Affleck in *Am. Phys. Educ. Review*, April and June, 1912.

[2] Described in paper read by Professor Bass before Am. Soc. H. and V. Engineers, July, 1913.

spaced at the ceiling of the room, and after being passed through an air washer, where it was cooled by the water about 15 degrees, it was returned to the room. The volume of air thus recirculated averaged 8.9 cubic feet per minute per pupil.

The results obtained in this room were compared with results in a room in the Adams School, the pupils in both rooms being of the same age, grade and general condition. The room in the Adams School was ventilated as is usual in the case of schoolrooms. The air was admitted through one opening above the blackboard and was exhausted through one opening near the floor on the same side of the room. The air was not washed and the volumes averaged 35.4 cubic feet per minute per pupil. The temperature averaged slightly lower and humidity slightly higher in the Jackson schoolroom.

The carbon dioxide averaged 12.5 parts per 10,000 in the Jackson School and 9.1 parts per 10,000 in the Adams School.

Dust counts showed 105,000 particles per cubic foot of air in the Jackson School and 225,000 in the Adams School. As a result of these experiments, covering a period of four months the conclusion is offered that

> it is impossible to demonstrate physical or mental deterioration due to the use of recirculated air. Neither is it possible to ascribe any discomfort on the part of the pupils or the teacher to this recirculated air.

The air washing, it is stated, was not sufficient to remove all odors, but they were reduced to such an extent that they were not offensive to persons occupying the room continuously, although noticed by persons entering the room.

In this experiment the problem of the use of recirculated air was combined with that of the use of a reduced volume of air delivered directly toward the face of the pupil. The two problems should be separately studied. More light on the effect of recirculated air is desirable, as is the case with reduced volumes of air directly delivered and generally distributed.

In the case of one of these experiments the volume of air used was more than ten times that customarily used for ventilating purposes, and in the other case the volume of air used was less than one third that ordinarily used. Experiments with the standard and other volumes of air with the standard and diffused methods of introduction are desirable.

Studies along these lines are planned by the Ventilation Commission in connection with its experimental plant in Public School No. 51, the Bronx, New York City.

The economy of air recirculation was presented by the writer in the *Am. Physical Education Review* of December, 1913. Very marked economy was credited to recirculation. This claim was disputed by Evans in the June issue of the *Heating and Ventilating Magazine,* the claim being made that the cost of fresh cold water required for cooling and dehumidifying the recirculated air offset the saving in heat. Actual experience proves that such is not the case. Professor Bass states that water cost three cents per day during his experiments, which is vastly less than the amount stated by Evans. Dr. McCurdy states that some water was used for cooling, but even with 40,000 cubic feet of air per minute recirculated the cost of the fresh water used does not appear to have been a serious item.

It is manifest that a large amount of heat is saved, and this certainly warrants the most careful study of the problem of recirculation. Should it prove in every way satisfactory a great step in advance will have been made in the field of mechanical ventilation. But it may not be recommended as yet.

D. D. Kimball,
Member of New York State Commission on Ventilation

CONDITIONS AT THE UNIVERSITY OF UTAH

AT the request of the president and with the authorization of the council of the American Association of University Professors, the secretary of the association recently visited Salt Lake City and spent four days investigating the conditions at the University of Utah which have led to the resignation of sixteen members of the university faculty. The purpose and the limitations of the scope of the investigation are indicated by the following extracts from the secretary's letter to the president of the university:

The situation that has recently developed at the University of Utah has aroused much concern throughout the country among persons interested in the work of the American universities, and especially among members of the university teaching profession. It has, however, been difficult for those at a distance to be sure that they had correctly gathered the essential facts of the case from the incomplete and more or less conflicting *ex parte* statements which have appeared in newspapers and periodicals. In particular, the statements made upon the two sides of the controversy appear to have failed specifically to join issue upon certain points of interest. It has, therefore, seemed advisable to the president of the American Association of University Professors, Dr. John Dewey, to send a representative of that organization to interview yourself and others concerned, with reference to the matters in controversy; and to endeavor to secure as full and impartial a statement as may be of the relevant facts. It is perhaps advisable to explain the nature of the interest which the Association of University Professors takes in the matter. It is coming to be a well-recognized principle that the general body of university teachers is entitled to know, with regard to any institution, the conditions of the tenure of the professorial office therein, the methods of university government, and the policy and practise of the institution with respect to freedom of inquiry and teaching. In the absence of information upon these points, it is impossible for members of the profession to judge whether or not the institution is one in which positions may be properly accepted or retained by university teachers having a respect for the dignity of their calling, a sense of its social obligations, and a regard for the ideals of a university.

It is, therefore, important to the profession that when criticisms or charges are made by responsible persons against any institution, with respect to its policy or conduct in the matters to which I referred, the facts should be carefully determined in a judicial spirit by some committee wholly detached from any local or personal controversy, and in some degree representative of the profession at large. It is in this spirit, and for these purposes, that information is sought in this instance. What appears to be particularly desirable, in the present case, is a fuller and more definite statement than has yet been made public upon certain matters of fact which still remain not wholly clear, but which are, presumably, not incapable of ascertainment.

Any information of this sort which—with your assistance and that of others—I may be able to gather, will be laid before the council of the association, and probably also before a joint committee representing this and other organizations. My own report and the findings of the committee will, no doubt, if the council see fit, eventually be made public. We, of course, assume that the administration of the university is equally desirous that all facts in any way pertinent be thus fully made known, and submitted to the impartial judgment of both the academic and the general public.

We therefore venture to count upon your aid in this attempt to draw up a complete and unbiased summary of the circumstances of the case; this, we hope, may be of some service to the university as well as to our profession.

A report upon the case may be expected as soon as a committee of the association is able to consider the evidence brought together by the investigation of the secretary.

THE PACIFIC ASSOCIATION OF SCIENTIFIC SOCIETIES

THE letter from Professor J. N. Bowman, secretary of the Pacific Association of Scientific Societies, published in SCIENCE for April 9, 1915, gives me the pleasant opportunity of placing on record certain interesting facts concerning the Pacific Association.

Men and women of science residing in the Pacific region were obliged to recognize that the demands upon time and money to enable them to attend the meetings of the American Association for the Advancement of Science, in the Eastern or Central States, were so severe as to be prohibitive to fully 99 per cent. of the 800 Pacific members. Inasmuch as the

American Association could not extend its influence efficiently over this region, because of the great extent of our country in longitude, and especially in order that the general scientific interests of the region should be united, it was determined by Professor Bowman and many of his colleagues in the universities and colleges of the Pacific region, and by others engaged in the applications of science, to establish an association of the principal scientific societies already existing in the Pacific area. The organization was effected some five years ago and the Pacific Association of Scientific Societies has been leading a vigorous and useful life. Annual meetings have been held in some of the leading educational centers, such as the University of California, Stanford University and the University of Washington.

Two years ago the council of the American Association for the Advancement of Science adopted the policy of organizing divisions of the American Association for the accommodation of those members who live at great distances from the chief centers of American population. In harmony with this policy, a Pacific Coast Committee was appointed to organize a Pacific Division. There was at once the question of the future of the Pacific Association, whose functions were in most essentials precisely those proposed for the Pacific Division. The men and the societies that were making a success of the Pacific Association were identically the men and the societies that would be expected to make a success of the Pacific Division of the American Association. Evidently there must be no duplication. The only practicable solution required that the Pacific Association should give up its identity and that the forces which were active in the Pacific Association should be active in the work of the Pacific Division. It was evident that the Pacific Division offered important advantages over the existing organization, in part from the resulting unification of general scientific interests throughout America. The problem was approached in a sympathetic and unselfish spirit by all concerned, especially by the officers and more active members of the Pacific Association, and by none more efficiently than by Secretary Bowman.

It has seemed to me that the Pacific Association of Scientific Societies, in giving up its existence, should have the principal incidents of its birth, activities and dissolution recorded in this manner as a matter of historical interest.

It should be recognized by every one, it seems to me, that the justification for moral and financial support afforded to scientific investigation rests finally upon the availability of the results for the welfare of mankind and the general progress of civilization. It is hoped that all men and women of the Pacific region who are sincerely interested in scientific research or in the spread of knowledge amongst the people will feel entirely at home in the Pacific Division of the American Association, for the encouragement of research and the dissemination of knowledge are preeminently, as every one knows, the functions of the Association and of all its Divisions. The sparsely populated condition of the Pacific region, which includes all United States territory lying west of the Rocky Mountains, as well as Mexico, British Columbia, Alaska and the Islands of the Sea, will unavoidably place a serious limitation upon the success of the Pacific Division unless a very large percentage of the scientists and friends of science in this region subscribe to its membership roll and join enthusiastically in promoting its plans. The yielding of generous support would on the contrary make success prompt and complete.

W. W. Campbell,
President American Association for the Advancement of Science

Mount Hamilton, California,
April 14, 1915

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

MINUTES OF THE COMMITTEE ON POLICY

Messrs. Nichols, Pickering, Woodward, Cattell, Noyes, Humphreys, Fairchild, Paton and Howard, of the committee, met informally in the private dining-room of the Cosmos Club on Monday, April 19, 1915, at 7 P.M. After dinner, the meeting was called to order by the chairman, Mr. Nichols.

The minutes of the meeting of December 31, 1914, were read and approved.

After full discussion a number of resolutions were recommended to the council. These were adopted by the council and are printed in its minutes.

A letter from Ex-president Eliot was read in which he made certain suggestions relative to the possibility of preventing overcrowded programs at the meetings. On motion, the permanent secretary was instructed to arrange, so far as possible, all general interest items in the first, or general, part of the program in order that they may be easily consulted.

Professor Pickering, from the subcommittee on the Colburn Fund, of the committee on research, presented a report.

Professor Cattell presented a report from the Committee of One Hundred on Scientific Research.

Professor Pickering presented a report from the Committee on Expert Testimony.

L. O. HOWARD,
Secretary

MINUTES OF THE COUNCIL

THE council met at 4.45 P.M., April 20, 1915, in room 37, new building of the National Museum, with Messrs. Fairchild, Nichols, Humphreys, Cattell, Kober, Shear, Taylor, Alsberg, Shantz and Howard present.

The meeting was called to order by the permanent secretary and Mr. Fairchild was asked to preside.

The committee on policy submitted a report through its chairman, Mr. Nichols, and, on recommendation of the committee, the following actions were taken by the council:

On nomination by the sectional committee of Section B, Professor E. Percival Lewis, of the University of California, was elected as vice-president of that section in place of Professor Frederick Slate, elected at the Philadelphia meeting, who was unable to serve.

On nomination by the sectional committee of Section H, Professor Lillien J. Martin, of Stanford University, was elected as vice- president of that section in place of Professor George M. Stratton, elected at the Philadelphia meeting, who was unable to serve.

A resolution was adopted requesting Dr. William W. Campbell, president of the association, to prepare a formal address for the San Francisco meeting in addition to his regular address to be delivered before the association at the winter meeting of 1916–17.

In view of the desirability of rapidly increasing the membership of the newly founded Section M (agriculture), the council, on resolution, directed that the entrance fee of five dollars be remitted for the present calendar year to new members in the Section of Agriculture who may join from the following national societies having a qualification membership:

Society for Promotion of Agricultural Science.
American Society of Agronomy.
The Society of Horticultural Science.
The American Society of Animal Production.
The Official Dairy Instructors' Association.

On motion, it was resolved to continue the subcommittee of the committee on research constituted at the Philadelphia meeting for consideration of the Colburn will fund.

Professor Roscoe Pound, of the Harvard Law School, was elected as a member of the committee on the amendment of the charter in place of Dr. Charles S. Minot, deceased.

An application from the Gamma Alpha regular program of the association when the Graduate Scientific Fraternity to allow a notice of its meeting to be inserted in the regular program of the association when the conventions of the fraternity were held at the same time and place as the meetings of the association was read and acted upon favorably.

On motion, the committee on policy was authorized to appoint a committee on the international relations of scientific institutions and scientific men.

The financial report of the permanent secretary for the fiscal year from November 1, 1913, to October 31, 1914, was read and, on motion, approved and ordered printed.

The permanent secretary reported briefly concerning the arrangements for the San Francisco meeting and announced that the

new volume containing the constitution, list of meetings, officers, committees, fellows and members was nearly ready for publication.

At 5.30 P.M., the council adjourned.

L. O. Howard,
Permanent secretary

SCIENTIFIC NOTES AND NEWS

Members of the National Academy of Sciences were elected on April 21, as follows: Dr. Charles Greeley Abbot, director of the astrophysical laboratory of the Smithsonian Institution; Dr. W. E. Castle, professor of zoology, Harvard University; Dr. G. Stanley Hall, president of Clark University and professor of psychology; Dr. Frank R. Lillie, professor of embryology, University of Chicago; Dr. Graham Lusk, professor of physiology, Cornell Medical School; Dr. Robert A. Millikan, professor of physics, University of Chicago; Dr. Alexander Smith, professor of chemistry, Columbia University; Dr. Victor C. Vaughan, professor of hygiene and physiological chemistry, University of Michigan; Dr. H. S. White, professor of mathematics, Vassar College; Dr. S. W. Williston, professor of paleontology, University of Chicago.

The following have been elected members of the American Philosophical Society: John J. Abel, M.D., Baltimore, Md.; Edwin Plimpton Adams, Ph.D., Princeton, N. J.; Walter Sydney Adams, Pasadena, Cal.; John Merle Coulter, Ph.D., Chicago, Ill.; Whitman Cross, Ph.D., Washington, D. C.; William J. Gies, M.D., New York City; Philip Bovier Hawk, Ph.D., Philadelphia; John Fillmore Hayford, Evanston, Ill.; Emory Richard Johnson, Sc.D., Philadelphia; John Anthony Miller, Ph.D., Swarthmore, Pa.; Thomas Hunt Morgan, Ph.D., New York; William Fogg Osgood, Ph.D., Cambridge, Mass.; Raymond Pearl, Ph.D., Orono, Me.; Theobald Smith, M.D., Boston, Mass.; John Zeleny, Ph.D., Minneapolis, Minn.

A banquet to Dr. William Henry Dall, commemorating the completion of fifty years service to science was given at the Cosmos Club, Washington, on April 21. Dr. Dall responded to a series of toasts which were as follows: Dall the Alaska pioneer, Dr. Alfred H. Brooks; Dall the anthropologist, Professor William H. Holmes; Dall the coast pilot, Mr. Isaac Winston; Dall the malacologist, Dr. T. Wayland Vaughan; Dall the zoologist, Dr. C. Hart Merriam; Dall the nomenclatorist, Dr. Ch. Wardell Stiles; Dall the poet, Justice Wendell P. Stafford; Dall the man, General A. W. Greely.

The Royal Society of Arts has presented its Albert medal to Senator Guglielmo Marconi "for his services in the development and practical application of wireless telegraphy."

At the annual dinner of the National Academy of Sciences, held on April 20, the Draper medal was presented to Dr. Joel Stebbins, professor of astronomy at the University of Illinois.

The Jacksonian prize of the Royal College of Surgeons, London, has been awarded to Mr. Jonathan Hutchinson for his essay on the pathology, diagnosis and treatment of trigeminal neuralgia, and the John Tomes prize to Mr. J. F. Colyer for his work on comparative dental anatomy and pathology.

According to a cablegram from Nish, Dr. Richard P. Strong, professor of tropical diseases in the Harvard Medical School, arrived there on April 24. He at once sat down to a long conference with the minister of the interior, Ljouba Jovanovitch, to discuss a plan of campaign against disease.

Dr. Samuel T. Darling, who was associated with General Gorgas for ten years on the Panama Canal, and who accompanied him to South Africa during his investigation of disease among the miners on the Rand, has resigned as chief of laboratory, and will investigate disease in the far east for the Rockefeller Foundation's international health commission. He left for Singapore via Liverpool on the *Adriatic* on April 21.

Dr. Frederick H. Getman, of Bryn Mawr College, has resigned as associate professor of physical and inorganic chemistry and will open a private research laboratory in Stamford, Conn., at the close of the academic year.

C. M. JANSKY, professor of electrical engineering at the University of Wisconsin, has accepted an appointment on the jury of awards in the electrical group of the machinery exhibit at the Panama-Pacific International Exposition. He takes up his duties at San Francisco on May 3.

DR. K. HIRAYAMA, professor of astronomy in the University of Tokio, arrived at San Francisco on April 19 for two years' research study in the United States, principally at Yale University. He will inspect the observatories of the country and seek suggestions for the advancement of astronomical work in Japan.

THE Anglo-Swedish Antarctic expedition, under the leadership of Professor Otto Nordenskjöld, has been postponed until the war has ended.

DURING part of March and April, Mr. Robert Cushman Murphy, of the Brooklyn Museum, conducted field work in the Lower California desert. The principal object of the expedition was to study and obtain specimens of the pronghorn antelope. The material collected is to be used in a large exhibit illustrating plant and animal life of the arid southwest.

PROFESSOR J. S. HUXLEY, of the department of biology, Rice Institute, accompanied by Mr. W. M. Winton, biological fellow, and Dr. W. C. Graustein, instructor in mathematics, visited the Texas College, April 17–19, for an examination of local fossils gathered by Professor Francis from the Brazos Valley, as a preliminary to a collecting trip planned for later in the spring.

AT the meeting of the New England Federation of Natural History Societies held last week in the building of the Boston Society of Natural History, Boston, the principal business was the reports of societies and the election of officers. More than twenty societies responded to the former with statements outlining their activities. The election resulted as follows: President, John Ritchie, Jr., Boston Scientific Society; vice-presidents, Arthur H. Norton, Portland Society of Natural History; Norman S. Easton, Fall River Society of Natural History; secretary, James H. Emerton, Cambridge Entomological Club, Boston; treasurer, Miss Delia I. Griffin, curator, Children's Museum, Pine Banks, Jamaica Plain.

THE members of Sigma Xi in the University of Oklahoma have organized a club to be known as the Sigma Xi Club of Oklahoma. Dr. Irving Perrine addressed the first regular meeting, on March 29, on the subject of "Some Problems in Oklahoma Geology." It is the purpose of the organization to stimulate scientific research in the University of Oklahoma and the secretary, W. C. Allee, desires to get in communication with members of Sigma Xi who are planning to pass through Oklahoma.

PROFESSOR T. B. BRODIE, professor of physiology in the University of Toronto, will deliver a course of four lectures on "The Gases of the Blood" at King's College, London, on May 31, June 2, 7 and 9.

M. EDMOND RIGAUX, of Boulogne, known for his work in geology and paleontology, has died in his seventy-seventh year.

DR. W. GRYLLS ADAMS, F.R.S., emeritus professor of natural philosophy and astronomy in King's College, London, died on April 10, at the age of seventy-nine years.

DR. OTTO N. WITT, professor of chemical technology in the Technical High School at Charlottenburg, died on March 23, aged sixty-four years.

A NEW publication called the *Illinois Chemist* will make its appearance at the University of Illinois in May. Four chemistry organizations will cooperate with the chemistry department in issuing this new quarterly. It will publish among other things, information in regard to research work—results of experiments, notes on the work of alumni in the science. H. D. Valentine has been elected editor and V. W. Haag, business manager.

IT is announced in *Nature* that the whole of the collections and library of the late Fortescue W. Millett, of Marazion and Brixham, have been acquired by Mr. Heron-Allen, and will be incorporated as a special section of the Heron-Allen and Earland collection, to which the collection of the late J. D. Siddall, of Chester, was also added recently. It is

hoped that this entire collection, numbering some 10,000 slides, and the library which accompanies them, will ultimately be incorporated with the Museum of Oceanography and Marine Biology, which it was the ambition of the late Sir John Murray to found. Broadly, his object was to form his collections of material and soundings into a department of the Natural History Museum in conjunction with the H. B. Brady and W. B. Carpenter collections, which are already there. The coordination of the Brady, Carpenter, Murray, Millett, Siddall, and Heron-Allen and Earland collections would form a reference museum of oceanic deposits and type specimens without an equal in the world.

The biological laboratory at Fairport is regularly open but the mess and special accommodations for temporary investigators will be available about June 15. There are opportunities and facilities for zoological and botanical investigations as well as for chemical studies relating to biological problems. Investigators desiring to occupy tables for any part of the season may communicate with the Commissioner of Fisheries, Washington, D. C., or the director of the station, Fairport, Iowa.

Professor Lawrence Martin, of the University of Wisconsin, is planning to conduct a party for summer field work in Alaska, stopping on the way at the Grand Canyon of the Colorado, the fault lines near San Francisco, and the California exposition. The trip is open to students from other universities and to teachers of geography and geology. It will start the middle of June or first of July and be gone about two months. Most of the time will be spent in camp along the fiords and in studying the glaciers of southeastern Alaska, including the Muir, Grand Pacific, Johns Hopkins and other ice tongues in Glacier Bay near the base of Mt. Fairweather (15,000 feet high), and the Taku, Norris, Eagle, Herbert, Mendenhall, Davidson, Denver, Sawyer, Dawes, Baird, Patterson, Le Conte and the Great Glacier of the Stikine. Examination of faults and other structures in the sedimentary rocks at the border of the coast range batholith, especially in relation to the origin of the fiords. Visits to gold mines, placer deposits, copper mines, marble quarries, gypsum mines, salmon canneries, native villages with totem poles, etc. Possible ascent of Mt. Edgecumbe, a dormant volcano near Sitka. Trip over Canadian Coast Range on White Pass and Yukon Railway. Students without previous training may work for credit in elementary geology and physical geography, while advanced students can take up special problems in physiography, structural geology, stratigraphy and glacial phenomena.

In connection with the 109th annual meeting of the Medical Society of the State of New York, in Buffalo, this week, a program of public lectures was arranged as follows:

Monday evening, April 26, "Public Health." Professor C.-E. A. Winslow, director, division of publicity and education, New York State Department of Health. Subject: "The New York State Department of Health and its Work." Illustrated. Dr. Charles J. Hastings, medical officer of health, Toronto, Ont. Subject: "What are We Doing to Improve our Race?" Dr. Francis E. Fronczak will preside.

Tuesday afternoon, April 27, "Child Saving." Julia C. Lathrop, chief of children's bureau, U. S. Department of Labor, Washington, D. C. Subject: "Why the Children's Bureau Studies Infant Mortality." Dr. Angenette Parry, New York City, president, Women's Medical Society of New York State, will introduce the speaker. The ladies' committee cordially invite all women to meet Miss Lathrop in the Reception Room of the Armory at five.

Tuesday evening, April 27, "Child Welfare." Dr. J. W. Schereschewsky, surgeon, Public Health Service, Washington, D. C. Subject: "The Relation of Heat to the Summer Mortality of Infants." Illustrated.

Wednesday afternoon, April 28, "Mentality of the Child." Henry H. Goddard, Ph.D., director, department of research, The Training School, Vineland, N. J. Subject: "The subnormal Child: Who is He and what must be Done for Him?" Illustrated.

Wednesday evening, April 28, "Safety First." Dr. Thomas Darlington, American Iron & Steel Institute, New York. Subject: "Welfare Work in Industry." Illustrated.

Thursday afternoon, April 29, "Prevention of Blindness." Edward M. VanCleve, managing di-

rector of the National Committee for the Prevention of Blindness, New York. Subject: "Saving Sight and Saving Citizens." Illustrated.

Thursday evening, April 29, "Conservation of Vision." Mr. Ward Harrison, illuminating engineer, Cleveland, Ohio, representing the Illuminating Engineering Society. Subject: "Right and Wrong Methods of Interior Illumination." Illustrated by booths.

THE Royal Geographical Society, as we learn from *Nature*, has received news of Sir Aurel Stein's explorations in Central Asia from April to November, 1914. The expedition started in April from Tunhuang, where it had halted to recruit after the trying campaign in the Lop-nor desert between Turfan and the northern boundary of Tibet. The cave temples of the Thousand Buddhas near Tunhuang were re-visited, and further interesting collections were made. The explorer followed the ancient wall for 250 miles, and found that it was constructed of fascines of reeds or brushwood, admirably adapted to check the wind erosion of the desert sands. Coins, pottery and metal fragments found near the surface made it possible to define the Chinese frontier posts with accuracy. Beyond the So-lu Hu Valley further remains of the same kind were found. While Sir Aurel Stein was hunting for remains of the Great Yuechi on Indo-Hun culture to the north, his surveyor, Lal Singh, examined the ruined town of Khara Khoto, and proved that this could be no other than Marco Polo's "City of Etzina," where in ancient times travelers bound for Karakoram, the old Mongol capital, used to lay in supplies for the march across the great desert. Here many Buddhist remains were found, and it was ascertained that the ruin of the city was due to failure to maintain the irrigation system. When he despatched his report Sir Aurel Stein had planned to examine Buddhist ruins round Turfan, while his surveyor was to undertake the exploration of the little-known desert ranges of the Kuruk-tagh between Turfan and the Lop-nor depressions.

THERE has recently been issued by the Bureau of Standards, of the Department of Commerce, a paper describing a Wheatstone bridge designed with especial reference to flexibility of use in measurements with resistance thermometers, and discussing the use thereof. The bridge is adapted to use with either the Siemens type or Callendar type of resistance thermometer, or with the potential terminal type of thermometer by the use of the Thomson double bridge method. The instrument is also arranged so that it may be completely self-calibrated. The 0.01, 0.001 and 0.0001 ohm decades are secured by varying, by means of dial switches, the shunts on three coils permanently connected in the measuring arm of the bridge. The sum of the resistances which are permanently connected is 2.5 ohms when the dials are set on zero, so that in order to measure resistances smaller than this a coil of 2.5 ohms is connected in the adjacent arm of the bridge. The entire electrical circuit of the bridge, coils, contact blocks, switches and connectors are totally immersed in an oil-bath thermostat, and special manipulating devices for the links and dials, etc., are provided. Details of construction are shown by photographs and briefly explained in the text. A new form of hermetically sealed coil, suitable for Wheatstone bridges, potentiometers, and similar apparatus, is fully described and record of its performance reviewed. Such construction eliminates the seasonal variations of resistance (with varying atmospheric humidity) found in coils of the usual types. The accuracy attainable with the bridge is such that resistances of one ohm or more can be measured to an accuracy of one part in 300,000 in terms of the unit in which the calibration is expressed. This corresponds to an accuracy of about 0°.001 for measurements with the platinum resistance thermometer. Low resistances, the accuracy of measurement of which is limited by variations in contact resistances, may be measured to about three millionths of an ohm. This figure, rather than the one given above for accuracy, represents the precision attainable in measuring small changes of resistance such as are usual in resistance thermometry.

THE nation-wide study of the lumber industry, which is being made jointly by the Department of Agriculture and the Department of

Commerce, and the other industrial and technical investigations and experiments which have been carried on by the Forest Service in the last two years, were discussed at a conference of Forest Service officials at Madison, Wis., on April 14 to 17. The Forest Service Laboratory, the Washington Office of Industrial Investigations, and each of the seven National Forest Districts were represented at the conference by specialists. Among the subjects discussed were: Cooperation of the Forest Service with industries, lumber distribution in the United States, utilization of low-grade lumber and mill waste, adaptation of manufacturing and grading to specific classes of consumers, unification and standardization of lumber grades, study and development of general markets for National Forest timber, mill scale studies, including technical methods, tallying, etc.; lumber depreciation and the collection and compilation of lumber price data.

UNIVERSITY AND EDUCATIONAL NEWS

Appropriations for two new buildings to meet the needs of the University of Ohio and for additional tracts of farm land west of the Olentangy have been voted through the finance committee of the lower branch of the legislature. These extensions would involve an expenditure of $340,000. A domestic-science building to cost $150,000 and a shop building for manual training to cost $120,000 are provided. Ninety acres of land would be purchased west of the Olentangy River at a probable cost of $70,000.

The department of geology of Oberlin College is to move soon from the old building to a modern home in the science quadrangle. The museum has recently added much valuable data, including a collection of paleozoic fossils carefully worked over, identified and labeled; a collection of gold and silver, lead, bismuth and other ores from Utah and Idaho; a considerable number of topographic coast survey and other maps, and a large collection of wall pictures.

Professor C.-E. A. Winslow has been appointed to the newly established Anna M. L. Lauder professorship of public health at the Yale Medical School. He will give up his connection with the New York State Department of Health and the Teachers' College to take up this work next fall, but will continue to act as curator of public health at the American Museum of Natural History.

Professor James F. Norris, head of the chemistry department and of the department of general science of Simmons College, Boston, has accepted the position of professor of chemistry and director of the chemistry laboratories of Vanderbilt University, Nashville, Tenn.

At the Massachusetts Institute of Technology Associate Professor Henry G. Pearson is advanced to the grade of professor of English and he will be placed in charge of the department on the retirement of Professor Arlo Bates at the end of the present academic year. The following assistant professors are advanced to the grade of associate professor in their respective departments: Dr. Robert F. Bigelow, zoology and parasitology; W. Felton Brown, freehand drawing; Harold A. Everett, naval architecture and H. R. Kurrelmeyer, German. Instructor Henry B. Phillips is advanced to assistant professor of mathematics, and assistant instructors K. C. Robinson and John E. Bird are advanced to the grade of instructor in mechanical drawing. Miss Ruth M. Thomas, research assistant in organic chemistry, is advanced to research associate in the same department. The title of Professor A. E. Kennelly is changed from chairman to director of the research division of the department of electrical engineering.

Mr. W. L. Mollison has been elected master of Clare College, Cambridge, in succession to the late Dr. E. Atkinson. He was second wrangler in the mathematical tripos of 1873, and was elected a fellow of Clare in that year.

DISCUSSION AND CORRESPONDENCE

THE PRESENTATION OF THE FUNDAMENTAL CONCEPTIONS OF MECHANICS

The recent discussion in Science of the fundamental equation in mechanics has sug-

gested that perhaps some readers might be interested in a method of approach to the accurate physical conceptions of force and mass which I have been using recently with apparent success, and which differs, I believe, from that found in any text-book. I have come to believe that except for the very unusual student the disciplinary value of a dogmatic, mathematical presentation of mechanics is small, and that it is better to arouse and maintain interest by progressing from matters of every-day experience by as easy steps as possible, following largely the development of ideas which history has shown to be the natural one.

For the sake of brevity, I shall have to give the steps merely in outline. In fairness, then, the reader should remember that the work is supposed to extend over a period of several weeks, giving ample opportunity for the illustration of the various conclusions by numerous examples and problems, only a few of which can be suggested here.

Physics is largely a study of forces, and of the motions and strains due to forces. We will begin, then, with a study of common forces.

A. Force

1. *Introduction.*—Common experience. Muscular sensations. ***Common effects of muscular exertion:***

(1) Gravitational force overcome — weight raised;
(2) Elastic force overcome—spring compressed or stretched;
(3) Frictional force overcome—sled dragged;
(4) Speed changed—ball thrown or caught;
(5) Direction of speed changed—stone whirled in circle.

To study these it is necessary to be able to compare or measure forces.

2. *Measurement of Force.*—It is simplest to use the first effect, for preliminary work. It is natural to assume, in agreement with common experience, that the effort or force required to lift a number of equal blocks of iron is proportional to the number of blocks, or, more generally, to the volume of iron lifted. For present purposes we will define the following as our units of force:

A kilogram weight (kg. wt.) is the force required to lift 128 c.c. of iron;

A pound weight (lb. wt.) is the force required to lift 3.55 cu. in. of iron.

We are now able to measure the forces required to produce the various effects mentioned above.

3. *Elastic Forces—Spring Balance.*—Stretch proportional to force. Hooke's Law. Calibration of spring balances for use where actual weights are inconvenient. Bending of a beam, stretching of a wire, twisting of a rod.

4. *Forces in Equilibrium.*—Two or more forces acting on a ring. Force table. Parallel forces acting on a beam. Non parallel forces acting on a derrick, etc. Definition of ***vector, vector sum, moment of force, lever arm.***

Experimental laws:

(1) The vector sum of all forces acting must be zero.

(2) The algebraic sum of the moments of force about any axis must be zero.

Chemical balance.—Use to compare weights. Calibration of a set of brass and iron weights for use as standard forces.

5. *Frictional Forces.*—Friction is evidently equivalent to a resisting force equal and opposite to the force necessary to move the sled or other body uniformly along a horizontal plane. Study friction of wood on iron and wood on wood.

Experimental laws:

(1) Frictional force depends only slightly on the speed of relative motion. Kinetic and static friction.

(2) Frictional force is directly proportional to the force pressing the two surfaces together. $F = \mu P$. Define coefficient of friction.

(3) Frictional force is independent of the area of contact.

(4) Frictional force varies with the nature of the surfaces involved.

(5) A body started with a certain initial speed s_0, is brought to rest in a distance which is inversely proportional to the coefficient of friction. This suggests that on a perfectly smooth horizontal surface ($\mu = 0$), a body would keep moving with constant speed.

Before we can determine the effect of a constant unbalanced force in changing the motion of a body, we must study some simple types of motion.

6. *Some Simple Types of Motion.*—(1) *Uniform motion* in a straight line with constant speed. Define velocity. $d = st$.

(2) *Constantly changing speed,* linear motion. Define acceleration of speed. Derive formulas: $s = at$; $d = \frac{1}{2}at^2$; etc.; and $s = s_0 + at$; $d = s_0t + \frac{1}{2}at^2$; etc.

(3) *Parabolic motion,* combination of (1) and (2) at right angles. Formulas.

(4) *Uniform circular motion.* Constant speed but constantly changing velocity. Derive $a = s^2/r$. Distinguish *tangential* from *centripetal acceleration.*

7. *Type of Motion Due to a Constant Gravitational Force.*—(1) Atwood's machine, balanced forces; speed constant.

(2) Atwood's machine, small unbalanced force; $d \sim t^2$; positive acceleration.

(3) Atwood's machine, small retarding force; negative acceleration.

(4) Ball rolling down an inclined plane, or Fletcher's apparatus; $s \sim t$, $d \sim t^2$; acceleration constant.

(5) Water jet against blackboard, parabolic path; $d \sim t^2$.

(6) Ball rolling off table; measure g. Same for all bodies.

Conclusion: The motion produced is one with constant acceleration.

8. *Variation of Acceleration with the Force Acting on a Given Body.*—(1) Atwood's machine, various small unbalanced forces.

(2) Frictionless carriage on smooth horizontal plane.

Conclusion: The acceleration is directly proportional to the force.

9. *Measurement of Force Required to Give Centripetal Acceleration to a Given Body.*—(1) Swing 50 or 100 gm. on the end of a rubber band or spiral spring and determine the stretch during rotation at a fixed rate. Measure the gravitational force required to produce the same stretch. Compute the centripetal acceleration and show that the force required to produce it is to the weight of the body as the centripetal acceleration is to the acceleration of gravity.

(2) The centripetal force in the case of a mass rotating in a horizontal plane and free to slide along a rod may be measured directly by the weight required to produce the acceleration. Make the same computation as in (1).

Conclusion: The unbalanced force required to produce centripetal acceleration is equal to that required to give the same body an equal linear acceleration. Combining this with the conclusion of §8 we see that the acceleration produced by an unbalanced force acting on any given body is proportional to the force and is in the direction of the force, whether it is tangential or centripetal.

10. *Nongravitational Forces, Magnetic, Electric, Frictional, etc.*—Can be balanced by gravitational forces; produce the same effect when unbalanced; can be measured in terms of the gravitational force which will balance them or which will give the same acceleration to the same body. From our experience with gravitational forces we generalize and assume that whenever a body is being accelerated it is being acted upon by an unbalanced force; and if the known forces acting on the body are insufficient to account for its acceleration, we immediately postulate the existence of another force and experiment to find out what physical properties of the body in question and of the other bodies concerned, determine the amount of the force.

We have studied the relative effect of various forces upon the *same body* and arrived at the important generalization that whether the acceleration produced be tangential or centripetal, it is proportional to the force and in the direction of the force. We will not study the effect of the same force on various bodies.

B. *Inertia or Mass*

11. *Introduction.*—The fact that force is necessary to change the velocity of any body implies a tendency to persist in uniform motion and to resist a change of motion. This property of bodies is called *inertia.* The easier it is to accelerate a body, the less its inertia, of

course. So it is natural to assume that the inertia of any body is proportional to the force (F) required to give it unit acceleration, or since acceleration is proportional to force and since the acceleration produced by unit force would be $1/F$, this is equivalent to assuming that inertia is inversely proportional to the acceleration produced by unit force.

12. *Inertia of Different Volumes of Iron.*—(1) Two carriages carrying two or three equal volumes of iron, accelerated toward each other by a stretched rubber band.

(2) Atwood's machine, same force, different volumes of iron.

Conclusion: Acceleration is inversely proportional to the volume of iron for the same force; therefore inertia is directly proportional to the volume of iron or to the amount of iron.

13. *Inertia of Equal Volumes of Various Substances.*—Assume that two bodies have the same inertia when the same force gives them the same acceleration. Using the same apparatus as in §12, we find that the ratio of the inertias or masses of any two bodies is equal to the ratio of their weights (at a given point on the earth).

14. *Units of Mass.*—Kilogram, gm., pound.

15. *Falling Bodies.*—Since the force acting is proportional to the mass of each body, the acceleration must be the same for all. This conclusion agrees with experiment.

C. Fundamental Law of Mechanics

16. *Summary:*

With same mass: $a_1 : a_2 = F_1 : F_2$.
With same force: $a_1 : a_2 = m_2 : m_1$.
With same acceleration: $m_1 : m_2 = F_1 : F_2$.
Combining these: $m_1 a_1 : m_2 a_2 = F_1 : F_2$.

17. *Fundamental Law.*—When any body is acted on by an unbalanced force, the acceleration produced is in the direction of the force, is proportional to the force and is inversely proportional to the inertia of the body acted upon.

18. *Gravitational Units of Force.*—Kg. wt., lb. wt. The units we have been using. If force is measured in kg. wt., mass in kg., and acceleration in cm. per sec. per sec. then

$$a = gF/m,$$

where g is the acceleration of gravity. The same equation holds for lbs. wt. and lbs. and ft. per sec. per sec. Variation of g with distance from center of earth. Units not absolute.

19. *Absolute Units of Force.*—Dyne, poundal. Independent of gravity. Simpler equation $F = ma$.

20. *Application to Various Special Cases.*—Atwood's machine, inclined plane, etc.

21. *Definition and Discussion of Momentum, Impulse, Work and Energy.*

I shall be very grateful for any suggestions in regard to the above outline, especially from those who are willing to concede that a departure from our present dogmatic method of presentation is advisable.

GORDON S. FULCHER

WISCONSIN UNIVERSITY
April 1, 1915

GET THE UNITS RIGHT

PROFESSOR A. GRAY in a recent lecture on Kelvin's work in gyrostatics, says:

> It is always a good thing to get down to numbers and it is a most healthful mental discipline to be forced to *get the units right.*

The force of this remark is apparent in following the discussion in SCIENCE relative to the best expression of the fundamental equation in mechanics. Professor Kent criticizes Professors Huntington and Hoskins, objecting to the form of the equation $F = ma$. He rightly says:

> The equation is not true in the ordinary English system (foot-pound-second) until it is hybridized by valuing either F or m in some other unit than pounds (poundal or gee-pound) or a in gravitals (instead of feet) per second per second (1 gravital $= 32.174$ feet) or else the letter m is explained as not being quantity of matter in pounds but only the quotient or ratio W/g. Neither is it true in the metric kilogram-meter-second system. . . . It is of course true in the dyne-centimeter-gram-second system but this system is only used in higher physical theory and it should not be inflicted on young students.[1]

[1] SCIENCE, Vol. XLI., No. 1055, p. 424.

Now what is the difficulty with the dyne-C.G.S. system and why not inflict it on the young? What is the present system, if not an infliction?

At Blue Hill Observatory we have for some time been expressing temperatures in degrees absolute, pressures both atmospheric and vapor, in kilobars or kilodynes, and rainfall in millimeters. Dr. Shaw, of the British Meteorological Office, has since May 1, 1914, published rainfall values in the daily weather report in millimeters and beginning January 1, 1915, the millimeter is used in the weekly and monthly weather reports. In nearly every part of the world except the United States the millimeter has supplanted the inch as the unit of rainfall measurement. Of course it will be adopted here before long. As Shaw points out, aside from the advantage of using a unit generally adopted, the unit of rainfall 0.01 inch used to define a rain day has been most unsatisfactory. A fall of 1 mm. (0.04 inch) is a much fairer definition and as a matter of fact we have had to publish this in addition to the former.

From the point of view of the engineer, the use of the millimeter facilitates computation and realization of the amount of water available over a given area. A millimeter of rainfall means a liter of water per square meter.

Any one who has lived in the western part of the United States and recalls the various miners' inches for measuring water depth and flow will realize that it would be far from being an infliction to have the C.G.S. units come into general use in engineering practise.

It is not so difficult to break away from the old units as may be imagined. A year's constant use of the C.G.S. units makes one feel like saying, when reading of inch measurements, "Inch, inch? Where have we met that term before?"

ALEXANDER MCADIE

HARVARD UNIVERSITY

A SPURIOUS CASE OF MULTIPLE HUMAN BIRTHS

In the *Boston Medical and Surgical Journal* for September 26, 1872, under the head of Medical Miscellany occurs the following item:

Eight Children at a Birth.—On the 21st of August, Mrs. Timothy Bradlee, of Trumbull County, Ohio, gave birth to eight children—three girls and five boys. They are all living, and are healthy but quite small. Mr. Bradlee was married six years ago to Eunice Mowery, who weighed 273 pounds on the day of her marriage. She has given birth to two pairs of twins, and now eight more, making twelve children in six years. Mrs. Bradlee was a triplet, her mother and father being twins, and her grandmother the mother of five pairs of twins.

This case has been quoted often both in general texts, such as Gould and Pyle, "Anomalies and Curiosities of Medicine," 1897, p. 153, and in special papers, such as Wilder, *American Journal of Anatomy,* Vol. 3, p. 393, 1904. From the Prussian statistics gathered by Veit, it has been shown that twins occur on the average once in 88 births, triplets once in 7,910 births and quadruplets once in 371,126 births. Cases of five or six children at a birth are well authenticated, but are so rare that no statistical statements concerning them can be made. Gould and Pyle, in commenting on these instances, declare that all cases thus far reported of more than six children at a birth are to be regarded as of very doubtful value. To this category belongs that of Mrs. Bradlee already quoted. As this instance is of comparatively recent origin, it seemed possible to learn something of its authenticity. A letter was therefore addressed to the county clerk of Trumbull County, Ohio, inquiring about the case, and through the courtesy of that official the following reply was received.

M. B. TAYLER,
CLERK OF COURTS,
TRUMBULL COUNTY
WARREN, OHIO, March 30, 1914

MR. G. H. PARKER,
Cambridge, Mass.

Dear Sir: I reply to your letter of the 24th inst., in regard to the item in the medical journal, would say that after inquiry I am informed that there is no truth in the statement. It seems that a practical joker of those days went into one of the newspaper offices here and set up an article which he succeeded in having printed in one or two copies of the paper and then took the article out and distributed the type in their proper places, and se-

curing the copies which had the article in, sent the same to a New York paper thinking he had accomplished a great joke. This is practically all the information I can obtain in regard to the matter but can state that there is no truth or foundation in the report whatever.

Very truly yours,

(Signed) M. B. TAYLER

It is clear from this reply that the case of Mrs. Bradlee, so far as the number of children is concerned, is spurious and ought to be dropped from the list of authenticated multiple human births.

G. H. PARKER

HARVARD UNIVERSITY

SCIENTIFIC BOOKS

Some American Medical Botanists commemorated in our Botanical Nomenclature. By HOWARD A. KELLY. Troy, N. Y., The Southworth Company. 1914. 8vo. 215 pp., 42 pl.

In this attractive and beautifully printed volume, which is at once a contribution to medical history and the history of botany, Professor Kelly has conceived the genial thought of giving some memorial records of American physician-botanists whose names have been commemorated in plants, some of which were discovered or first described by them. This eponymic practise was introduced by Linnæus, who, when he found some guest or disciple to be heartily interested in botany, would often dedicate a new genus or species to him. Before Linnæus, plants were called after the names of the saints, *e. g.*, St. John's wort, St. Ignatius beans, etc.; and Pliny gives Eupatorium as the cognomen of Mithridates, King of Pontus, who discovered its virtues. Some of the eponyms formed from proper names were very inharmonious or barbarous, *e. g.*, ***Andrezejofskya, Eschscholtzia*** (Chamisso), ***Sirhookera*** and ***Peckifungus*** (Kuntze). Some of these names were even misspelled, *e. g.*, ***Wisteria*** for Wistar, but on the whole, what Kelly calls "amical floral nomenclature" was a pleasant practise, particularly in the eighteenth century, when friendly relations between European and American physicians were very close indeed. It is worth while to list Dr. Kelly's remarkable series of botanist-physicians with the plants attached to their names. They are:

Michel S. Sarrazin (1659–1734)—***Sarracenia purpurea*** (Tournefort).

John Mitchell (1680–1768)—***Mitchella repens*** (Linnæus).

Cadwalader Colden (1688–1776)—***Coldenia procumbens*** (Linnæus).

John Clayton (1693–1773)—***Claytonia Virginica*** (Gronovius).

John Bartram (1699–1777)—***Lantana Bartramii*** (Baldwin).

Alexander Garden (1728–1792)—***Gardenia jasminoides*** (Ellis).

Adam Kuhn (1741–1817)—***Kuhnia Eupatorioides*** (Linnæus).

Moses Marshall (1758–1813)—***Marshallia trinerva*** (Schreber).

Caspar Wistar (1761–1818)—***Wistaria speciosa*** (Nuttall).

Benjamin Smith Barton (1766–1815)—***Bartonia decapetala*** (Muhlenburg).

David Hosack (1769–1835)—***Hosackia bicolor*** (Douglas).

William Baldwin (1779–1819)—***Baldwinia uniflora*** (Nuttall).

William Darlington (1782–1863)—***Darlingtonia Californica*** (Torrey).

James Macbride (1784–1817)—***Macbridea pulchra*** (Elliott).

Jacob Bigelow (1787–1879)—***Bigelowia Menziesii*** (De Candolle).

Charles Wilkins Short (1794–1863)—***Shortia galacifolia*** (Gray).

John Torrey (1796–1873)—***Torreya taxifolia*** (Arnott).

Zina Pitcher (1797–1872)—***Carduus Pitcheri*** (Torrey).

Charles Pickering (1805–1878)—***Pickeringia Montana*** (Nuttall).

John Leonard Riddell (1807–1865)—***Riddellia tagetina*** (Nuttall).

George Engelmann (1809–1884)—***Engelmannia pinnatifida*** (Torrey).

Alvan Wentworth Chapman (1809–1899)—***Chapmannia Floridana*** (Torrey & Gray).

Asa Gray (1810–1888)—***Lilium Grayii*** (Hooker & Arnott).

Arthur Wellesley Saxe (1820–1891)—***Rumex Saxei*** (Kellogg).

Charles Christopher Parry (1823–1890)—***Lilium Parryi*** (Watson).

Elliot C. Howe (1828–1899)—*Stropharia Howeana* (Peck).
William Herbst (1833–1907)—*Sparassis Herbstii* (Peck).
George Edward Post (1838–1909)—*Postia Lanuginosa* (Boissier & Blanche).
Joseph Trimble Rothrock (1839–)—*Rothrockia cordifolia* (Gray).
Harry Hapeman (1858–)—*Sullivantia Hapemani* (Coulter).

The biographies of all these worthies are presented in exhaustive and attractive style and will be a valuable source of reference to the future medical historian. Some of them, such as Adam Kuhn, B. S. Barton, Jacob Bigelow, George Engelmann and Asa Gray, are, of course, of great importance in the history of American botany. Alexander Garden, of the gardenia, or cape jessamine, was a prominent figure in the group of South Carolina physicians which Welch has pronounced to be the most important in the colonial period. The volume is extensively illustrated with rare portraits, facsimiles and beautiful photographs of the plants. To Dr. Kelly's friends it will always have a personal interest because he has put so much of his lovable self into it.

F. H. Garrison

Army Medical Museum

The Deaf. Their Position in Society and the Provision for Their Education in the United States. By Harry Best. New York, Thomas Y. Crowell Co. 12mo. Pp. 340. Cloth.

There is, perhaps, no more accurate indication of the state of civilization reached by any people than the extent to which its handicapped classes are assisted to overcome their disadvantages and to approach a normal position in society. Judged by this standard, the people of the United States are rapidly advancing. Mr. Best has gathered a mass of very valuable data concerning a much-misunderstood class and embodied it in his book in a clear, intelligent and interesting arrangement.

It would be well if some way could be found to compel the reading of this book by every commissioner of education in the country, as well as by others to whom the citizens have entrusted the shaping of educational procedure. The problem of the deaf has passed from the realm of charity to that of education, and the solution of it has become an integral part of the task of every public-school system. If the knowledge contained in Mr. Best's book could be assimilated by those in educational authority throughout the country, the deaf would be immensely benefited.

Like every other human activity that has not as yet been reduced to an exact science, the effort to enable the deaf to overcome their great handicap opens the way to many differences of opinion as to how it can be most efficiently accomplished.

Mr. Best endeavors to state the facts and let his readers arrive at their own opinions. But he very properly sums up his book in a few general conclusions.

He finds the matter of paramount importance to be the preventing of deafness, and that, up to the present time, this has received only minor attention, but is likely to receive a greater proportion hereafter because of the present general warfare against disease, and the campaign for eugenics. He points out that the two elements to be principally controlled are consanguineous and syphilitic marriages, as well as marriages between persons having deaf relatives, and second, the element of watchful supervision over the ears in connection with such diseases as scarlet fever, meningitis, measles, etc., since three fourths of the cases of adventitious deafness come as a secondary result of infectious diseases. Fifty-two per cent. of the cases of total deafness occur before the age of two years. If, through some agency like the "Child Bureau" of the national government, parents could be informed of the exceptional danger to the hearing during the first two years of life, they might be induced to secure more medical supervision of their children's ears, noses and throats during the early years. That, combined with increased intelligence concerning this matter on the part of physicians, would reduce the percentage of early deafness.

Second in importance to the prevention of

deafness comes the education of the deaf. Mr. Best calls attention to the extraordinary fact that in many states the laws for compulsory education do not apply to the deaf, whereas they ought to apply to them with greater force than to the hearing, as the deaf are in more extreme need of special training. He says that "in the wide sweep of education the deaf have been the gainers as no other people in the world have been." "Yet," he continues, "the victory of the deaf is not complete. So long as people look upon them as an unnatural portion of the race; as of peculiar temperament and habits . . . just so long will the deaf be strangers in the land in which they dwell." He goes on to say that "there is still more or less conflict as to methods (of instruction), but this does not seem vital to the success of the schools." In this opinion it would seem that Mr. Best is mistaken. The one thing that makes the deaf "strangers in the land in which they dwell" is the use of a foreign language, the language of the fingers and of gesture. This situation has been created by the "*method*" by which they have principally been educated. That the employment of these silent means of communication is not necessary is amply demonstrated by the fact that *all* the deaf children of Massachusetts have for many years been educated wholly by means of the common communication of the race without recourse to the foreign language of the hands, and that the largest school for the deaf in the world, the Pennsylvania Institution for the Deaf, is so conducted. If this can be done in Massachusetts and Pennsylvania, what state is willing to acknowledge that the intelligence of its citizens and the extent of its educational capacity is less than that of any other state? It would seem, therefore, that the *method is vital* to the success of the schools in gaining a complete victory.

Mr. Best finds that 18.2 per cent. of those born deaf can use speech as a means of communication. Are the other 82 per cent. of too low an order of intelligence to acquire this ability? Certainly not. They have not acquired it because they were not given the same chance fortunately enjoyed by the 18 per cent. who were taught by the proper methods.

At the opening of a chapter on "The Use of Signs as a Means of Communication," the author says: "Deaf children can not be educated as other children, and in the schools there have to be employed special means of instruction." So far as this "special means of instruction" refers to the use of a language of the hands in communication the statement is entirely false. Deaf children have been educated in large numbers without special means of communication, and it has been the error into which this writer has fallen that has been largely responsible for the isolation of great numbers of the deaf. This error was brought here by an unfortunate chance, from France, where it was long since abandoned. But, as the author points out, the trend of progress is plainly indicated to be away from the initial error of silent methods and toward the normal speech method.

There can be no objection to deaf adults using any form of communication between themselves that they desire or find convenient, and the ability to use the sign language and finger spelling can be acquired by any one in a very few weeks. But an ability to communicate with hearing people by means of speech and speech reading can not be acquired except through long and patient effort from childhood and should therefore be used exclusively during the educational period. As the use of the speech method becomes more universal the "differentiation from the rest of their kind," and the lack of absorption in the body politic to which the author refers will steadily decrease, since they will no longer be so largely "removed from the usual avenues of intercourse."

Mr. Best finds that though an early disappearance of deafness does not seem likely, it is apparently decreasing. His second chapter is entitled "The Deaf as a Permanent Element of the Population." His third chapter takes up the deaf with relation to the state; the attitude of the law and of legislation toward them. He finds that "legislation discriminatory to them has practically disappeared, and in judicial proceedings particular usage has almost entirely passed away."

Chapter four takes up the "economic con-

dition of the deaf." He states that "50 per cent. of the deaf over 20 years of age are reported in gainful occupations, the percentage for the general population being 50.2 per cent. In the five great occupations, agriculture, manufacture, service, trade and professions the proportions are about the same for the deaf and the general population. Their own achievements have thrown out of court the charge that they are a burden upon society."

John D. Wright
The Wright Oral School,
New York City

Natural Sines to Every Second of Arc, and Eight Places of Decimals. By Emma Gifford. Published by Mrs. Gifford, Oaklands, Chard, Somerset, 1914. Pp. vi + 543. Price £1.

It is evident to any one who takes the trouble to consider the matter that this is an era of efficiency in the computations of the laboratory and observatory as well as in the work of the great industrial plants of the world. The astronomer, the physicist, and he whom Sir George Greenhill often delights to refer to as the "mere mathematician" are all conscious that the time is past when the individual investigator should compute if he can get some instrument, human or mechanical, to do this work for him. And so we have in our day a remarkable surging forward of the flood of computing devices—slide rules of many types, listing machines, comptometers, cash registers which mechanically add, and all sorts of other devices which do for the computer what he one time was forced to do for himself at great expenditure of energy. And we also have, but in less marked degree, a number of new tables, ingenious little ones like those of Professor Huntington, and ponderous newly-computed ones like those on which M. Andoyer is still engaged. All these aids to computation are healthy signs that the scholar joins the "sharp-lined man of traffic" in seeking the greatest efficiency in his exhausting labors.

Of the recent tables for saving the time of the computer no one is more noteworthy than the one of natural sines which has been computed and recently published by Mrs. Gifford. Georg Joachim computed such a table to ten figures and to every ten seconds, and this was published in 1596, after his death. This table was again printed in 1897, but was carried to only seven figures. Mrs. Gifford, however, has prepared a table extending one figure further than this, namely, to eight places, and has carried it to every second instead of every ten seconds. It is therefore apparent that here is by far the most complete table of natural sines that has ever been attempted. And not only is it the most complete but it is a model of convenience, so that the computer who has occasion to use a table of this kind will have good reason to thank Mrs. Gifford for her great care and patience.

It is hardly possible that such a table can be free from errors, particularly in cases where the last figure is near 5. Aside from this, however, a rather extensive use of the work by one computer for some months has revealed only a single error, namely, in sin 56′ 40″. Mrs. Gifford is correcting the tables in this and other minor respects, however, before issuing them.

The tables should have place in every college library and in every physical laboratory, observatory and mathematical workshop.

David Eugene Smith

Principles of Physics. By Willis E. Tower, Charles H. Smith and Charles M. Turton. P. Blakiston's Son & Company. 1914.

The teaching of high-school physics presents difficult problems. For each teacher there is undoubtedly a "best" text, and it is highly desirable that every teacher have a number of good texts from which to make the selection that seems, in practise, to be the best suited to himself. For this reason the text of Tower, Smith and Turton should be welcome. It does not claim to possess striking peculiarities, but rather to incorporate the best ideas found through extended experience of the authors.

The authors have attempted to adopt what they consider to be the conclusions reached by the "new movement in the teaching of physics." An introductory chapter is followed by one which is given to the explanation of a

selection of common things discussed under the title, "Molecular Forces and Motions." Here occur discussions of the diffusion of gases, the evaporation, diffusion and capillary action of liquids, crystallization, elasticity and general properties of matter. This introduction covers eight of the seventy-seven sections into which the book is divided, each section containing material enough for one recitation. The order of treatment of the subjects is as follows: Mechanics, Heat, Electricity, Sound, Light. By summarizing at the close of each section the important topics treated therein, and by setting problems which are related to the life of the pupil as well as to the principles of physics, the authors have made a special effort to produce a helpful book. Mathematical expressions are not avoided, but are used only where they are of apparent advantage to the student; indeed this advantage should be the only justification for mathematical expressions in either elementary or advanced physics. The illustrations, in both number and selection, are to be commended. The volume is distinctly a text-book, all of which is to be taught in the year's course in physics, save perhaps some of the numerous exercises which are found at the close of each lesson. The value of the work can only be ascertained by experience in the class room, but the spirit of the authors and their apparent success in applying it in the preparation of this book must commend the text to the consideration of every high-school teacher.

G. W. STEWART

SPECIAL ARTICLES

ANTAGONISM AND BALANCED SOLUTIONS[1]

THE term *antagonism* came into general physiology from medicine, where it was used in the seventies by Rossbach, Luchsinger and others to designate the opposing types of physiological action produced by certain chemical substances. Luchsinger, Langley, Sydney Ringer and others applied the term to that type of physiological situation seen in the opposite effects produced by atropine and pilocarpine on the sweat glands. One alkaloid, atropine, stimulated the activity of the gland, the other depressed it, and one effect could be made to partly or wholly supersede the other by the proper adjustment of the concentration and quantity of alkaloidal solutions used. It was found possible to establish physiologically equivalent quantities of each alkaloid which would exactly nullify the action of the other when applied to the tissue, and a given physiological result could be calculated from given quantities of the antagonistic substances. As Luchsinger saw it, the action of these substances was like algebraic *plus* and *minus* and came back to mass action (Massenwirkung) and affinity, a view accepted in effect by Langley and Ringer. In these experiments physiological antagonism meant opposing action on a definite function as a criterion. Contraction of the frog's heart, action of the salivary gland and contraction of the pupil of the eye were examples of such criteria.

In work of this type the antagonists were used in simple solutions applied serially to the tissues in question, and the fact of antagonistic action was demonstrated by the disappearance of the action characteristic of the first substance upon the application of the second substance. The simultaneous application of the antagonistic substances seems not to have been made.

Work of this type developed a number of important differences in the behavior of supposed antagonists. Luchsinger found when the activity of the sweat gland of the cat was used as a criterion that pilocarpine and atropine produced opposite actions and that each was able to efface the other as wave-hollow effaces wave-crest or as algebraic plus effaces algebraic minus. This ability of each to efface the other and to produce the opposite physiological state in either order of application Langley proposed to call mutual antagonism.

This clean-cut, two-way, type of result, however, was not the rule, and for two chief reasons. (1) It was unusual that the action of two substances should cover precisely the same area of function and thus fully oppose each other throughout their effects. As a result,

[1] Published by permission of the Secretary of Agriculture.

one was likely to cause changes in some structure not affected by the antagonist, hence side effects turned up to confuse the issue. This trouble was due to the fact that more than one function was affected and the criterion had thus become complex. (2) A second difficulty arose from differences in the point to which a given action was referred. For example, Luchsinger found that pilocarpine stimulated the activity of the sweat gland of the cat to a point *above* normal activity, while atropine brought it *below* the normal rate. In carefully adjusted doses of physiological equivalents, the resultant action was a normal rate. Here the point of reference was the normal rate of activity and activities could be counted as plus or minus. When, however, Ringer tested the action of atropine and muscarine on the beat of the isolated frog's heart another type of situation developed. When the heart was treated with muscarine the beat sank to zero or near it. When it was treated with atropine depression also resulted, but only to such a degree as to clearly slow the beat. Both were thus depressants, although in unlike degree. When a "muscarine" heart was treated with atropine it was apparently stimulated, since the beat rose to the rate characteristic of atropine, but, with reference to the normal beat, it still remained depressed. When an "atropine" heart was treated with muscarine no change of beat was seen, muscarine being clearly not able to antagonize atropine. Here two substances acting alike as depressants are called antagonists not because one can raise the action above normal or even to it after depression by the other, but because one is able to efface the other and bring up the action to its own characteristic rate. Here the antagonists are both minus quantities with reference to normality and the result is the lesser minus quantity. Ringer called this a case of antagonism; it was not, however, mutual antagonism, since only one was able to replace the other and no opposite physiological state was produced. These two instances are clearly different in important particulars.

A little later, Ringer, working with small organisms placed in salt solutions, introduced still another phase of the problem. The quantitative plus and minus action, seen when the effect exerted on the single function was taken as the criterion, following successive applications of the chemical substances, was replaced by the action produced by a mixture of ions acting on the total organism. Here the effect of substances in simple solutions on the survival time gave the pure effect of each substance. The antagonistic action could not be tested as heretofore by successive exposures to the substances concerned, since death was the point sought in the experiment. Consequently a change of method was introduced by testing the organisms in mixtures of different proportions. A new sort of result appeared also. With a definite function as a criterion, antagonists merely offset each other more or less completely, the range of results being above or below the normal mark according to the magnitude of the stimulating action of one or both of the antagonists. No resultant action seen was more favorable than that of the more stimulating antagonist. A new feature, therefore, appeared when Ringer found that organisms sometimes lived longer in mixtures of salts than in the most favorable of the components. The term antagonism was again extended by Ringer to cover this third type of situation.

The introduction of life or death, the survival time, as the criterion, complicated the problem in at least one important way. Since in a more or less orderly manner, death means that one or more functions break down or cease to correlate. Hence a disturbing influence introduced by a given ion may harm one function and bring about death, another ion may affect an entirely different function and in a quite different way bring about the same visible response. Hence several ions may all be operating in a cell entirely independently of each other as regards function, and bring about an unvarying response. Death is the uniform result following from a variety of types of injury in the organism. Here, all idea of antagonism, as originally defined, may be absent, owing to the possibility that ions may not meet each other in physiological opposition in any one function. With death as the criterion it seems that one is hardly justified in asserting

antagonism unless it can be shown that somewhere in the complex of reactions one or more functions have been oppositely affected by the supposed antagonists. Death gives an unanalyzed result in which antagonisms may or may not have played a part.

The ideal criterion would be a single clear-cut function that by acceleration or by retardation in its activity would give information concerning the way in which definite external factors affect it. It is difficult, perhaps impossible, to carry the physiological analysis thus far, but the use of any one function that gives results capable of quantitative expression simplifies the problem and approaches more closely to certainty that antagonisms do exist. It is not to be understood that the survival time (death criterion) can not indicate antagonism in a rough way, but only that it does not necessarily indicate it.

What, then, is antagonism? In general, the historically established sense in which it came into general usage among physiologists should be retained as long as it clearly covers the idea with which it was associated. As new conceptions enter they should be designated in fitting terms, in order that confusion may be avoided. In the original sense in medicine, antagonists were much the same as antidotes, antagonists being sought for poisonous substances. Here clearly the idea of the physiological effacement of one by the other was generally accepted. Oftentimes a restoration to the normal was a result of such effacement, but such was not necessarily the case in order to have antagonism. Sometimes, each of the antagonists could efface the other and produce the opposite physiological state, illustrating mutual antagonism, but more frequently one antagonist only was able to efface the other, illustrating simple antagonism. The work developing these results was based on the serial application of the solutions to the organ. We are now confronted with the fact that, in mixtures of salts, the growth rate, survival time, or quantity of ions absorbed, as possible criteria, is found to exceed that observed in the sum of the actions of the constituents in unmixed solutions.

If we recur to Luchsinger's conception of algebraic plus and minus we interpret the frequently observed increment above the expected result not only as indicative of the physiological effacement of one constituent by the other, but as indicative also of an effect beyond simple physiological opposition. It is antagonism in the historic sense of animal physiology plus something else. By Osterhout this increment over the results to be expected on the basis of the effacement of the effect of one antagonist by that of the other, the "something else," is proposed *as a measure of antagonism.* It seems to the writer that this effect comes not from the physiological opposition of the constituents, but rather from their cooperation in the cell in affecting favorably the total balance of cell activities. It is hard to see in this favorable action merely an expression of physiological opposition; it appears much nearer to the "synergism" of the older physiologists, a term used to designate physiological cooperation as opposed to antagonism.

In our present uninstructed condition concerning the activities at play in the living cell, it is hard to see how any scheme can at this time be proposed by which we can designate the degree in which ions entering the plant come into physiological opposition in the manifold functions likely to be affected by them. The result obtained by the investigator is the resultant of an indefinite number of interactions on few or many functions, and we can not assess its separate antagonisms and "synergisms." We are only able to say whether this result is above or below that obtained in the control medium. This control medium may furnish merely a fixed point for comparison or it may in addition also furnish an expression of normality.

In sea water we have the interesting case of a balanced solution, a mixture of salts, each by itself toxic in the concentration present in the natural medium, but in the mixture seen in the sea water, not only capable of sustaining life, but of nourishing marine organisms in so far as the ash constituents go. It is evident, since the individual constituents cause death under circumstances hardly explicable on the basis of nutritional failure, that we have here a group of antagonisms and synergisms so

operating that all functions are sustained in effective cooperation. Not only do the different salts mutually offset each other's physiological deficiencies, but they are able to offset the usually harmful action of the solvent. Loeb has found an interesting experimental subject in *Fundulus,* a fish which is at home not only in the complete mixture, but which likewise survives for a time in distilled water. In the case of organisms which survive indefinitely in distilled water, it is likely that many do so largely by virtue of the salts contained in their own bodies. In general it appears that pure water extracts ions more or less rapidly from many plants and animals, and in case the experimental organism in question is of considerable size and the volume of water sufficiently limited the medium may easily get enough ions from the experimental plant or animal to offset the harmful action of the pure water. The ability of *Fundulus heteroclitus* to part with considerable quantities of salts to fresh water without immediately evident injury has been shown by Sumner. This fish is, however, hardly typical of marine organisms as a whole. In the red algæ, incomplete mixtures are injurious, as in *Fundulus,* but, unlike it, they are promptly killed by distilled water, which for them must be listed with the other constituents which, taken individually, act as fatal poisons. In this case, the mixture of salts is required to antagonize or efface the action of the water. A harmful action has been shown to characterize distilled water when used as a medium for various land plants as well, and to antagonize or efface this harmful action certain mixtures of salts, strikingly reminiscent of sea water in many important points, the so-called nutrient solutions, were long since devised by Knop, Sachs and others. It has been shown more recently by Osterhout and others that the so-called nutrient salts are toxic to land plants when taken individually in much greater dilution than has been generally supposed.

In both sea water and the more or less dilute nutrient solutions present in the soil, normal life is sustained as a rule only in mixtures of proper proportions and necessary concentration. Since salts are required in both cases to overcome the harmful action of pure water, as well as that of the salts themselves, there seems to be no reason to seek to limit the use of the term "balanced solutions" in the manner suggested by Loeb and Osterhout. Unless we admit that malnutrition due to a deficiency in nutrient salts is a form of toxicity excited by the substances present, we can hardly escape the alternative proposition that the missing salts are injurious *in absentia.*

Rodney H. True

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ON THE OSMOTIC PRESSURE OF THE JUICES OF DESERT PLANTS

In 1907 Drabble and Drabble[1] argued from a series of plasmolyzations of the leaf cells of a number of British plants from a range of habitats that physiological dryness of the substratum is the primary factor in the determination of the osmotic strength of the contents of the leaf cells of flowering plants. About four years later Fitting[2] applied the plasmolytic method in an extensive reconnaissance physiological study of the vegetation of the rocky peaks and slopes of the Chaine de Sfa and the adjacent lowlands, comprising concentrated salt marsh and arable oasis. Here he reports some enormously high concentrations of cell sap, such indeed as would theoretically give pressures of over 100 atmospheres if confined in suitable semipermeable membranes surrounded by pure water.

The results of these two papers force upon one the conviction that observations of the concentration of the cell sap may form a legitimate, and indeed essential, feature of comprehensive and thoroughgoing ecological or phytogeographical study.

One must note, however, that the number of observations from each habitat studied by Drabble and Drabble was small, and that their maximum intensity of dryness was not very great. Again, there is no satisfactory series of determinations of the osmotic pressure of the sap of mesophytic plants to serve as a

[1] Drabble and Drabble, *Bio.-Chem. Jour.,* 2: 1907.

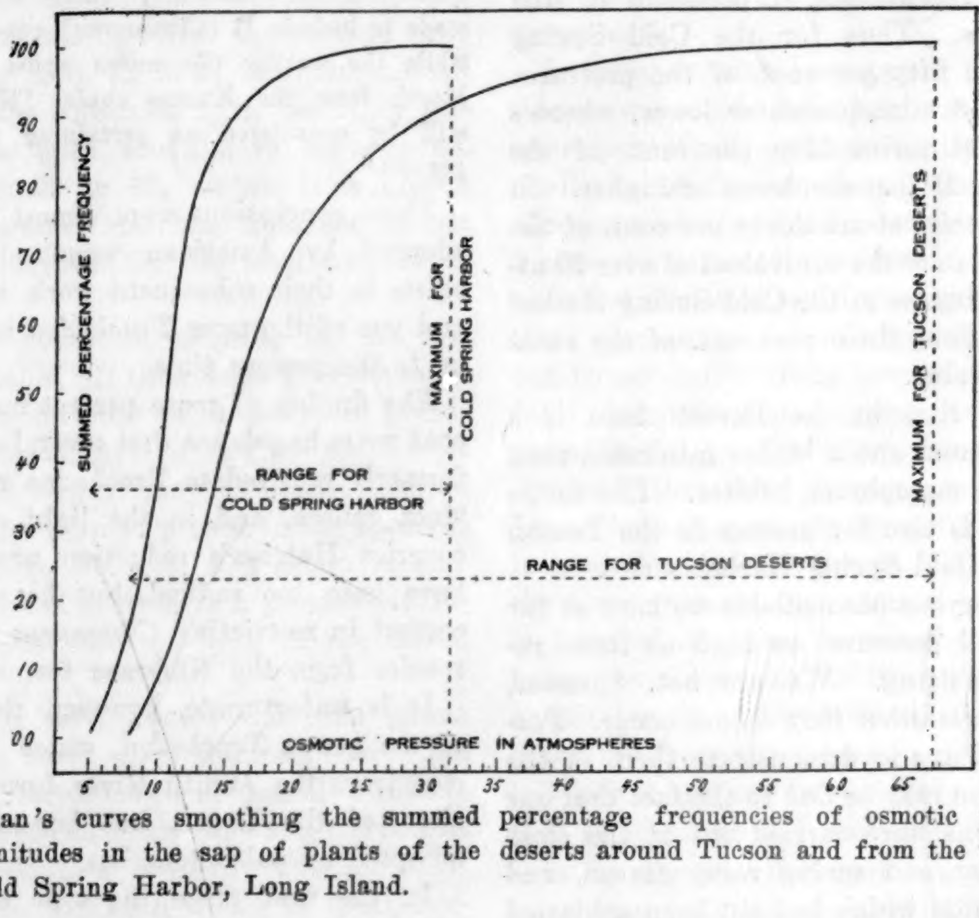
[2] Fitting, *Zeitschr. f. Bot.,* 3: 1911.

basis of comparison for Fitting's xerophytic series. Furthermore, both investigations were carried out by the use of plasmolytic methods, the accuracy of which when used under any but the most ideal conditions is open to some doubt.

Finally, the possibility of the existence within the living plant tissues of concentrations so high as these reported by Fitting has been questioned by plant physiologists.

It has therefore seemed to us highly desirable that further series of evidence should be gathered. Such data to be of real value should comprise extensive series of as nearly as possible comparable determinations from desert and moist regions. The technique which seemed to us the most trustworthy is the well-known freezing-point lowering method.

The director of the department of botanical research of the Carnegie Institution of Washington made it possible for two of us to carry out a series of cryoscopic determinations on the spring flora of the vicinity of Tucson, Arizona, during February, March and April, 1914. As a basis of comparison determinations on species of the spring and early summer native and naturalized flora of the vicinity of the Station for Experimental Evolution were made.[3] Each series comprised not far from two hundred determinations based on a large number of representative species. Cacti are excluded from the comparison because of known peculiarities.



Draughtsman's curves smoothing the summed percentage frequencies of osmotic pressures of various magnitudes in the sap of plants of the deserts around Tucson and from the various habitats near Cold Spring Harbor, Long Island.

The results will ultimately be published in detail. Preliminarily the differences between the two regions are most convincingly brought out by the accompanying diagrams. In these the actual frequencies of osmotic pressures[4] of various magnitudes have been

[3] The methods used were those already described (see Gortner and Harris, *Plant World*, 17: 1914), except for the fact that the freezing-point lowerings were determined by vaporization of ether in a Dewar vacuum tube jacket surrounding the freezing tube in which the bulb of the Beckmann thermometer was inserted.

[4] These are obtained directly from the depressions of the freezing point, corrected for super-

reduced to a percentage basis and these relative frequencies summed from the beginning for each successive grade. The curves are merely draughtsman's curves smoothing the empirical frequencies, but for present purposes they are quite good enough.

From such curves one may read off at once the relative frequencies of pressures of different grades. Thus for the Cold Spring Harbor series fifty per cent. of the pressures are about 10.5 atmospheres or lower, whereas in the Desert series fifty per cent. of the pressures are 15.7 atmospheres or higher. In the Tucson series about thirty per cent. of the concentrations are the equivalent of over 20 atmospheres, whereas in the Cold Spring Harbor series only about three per cent. of the cases exceed this value.

Note also that in the Desert there is a higher maximum and a higher minimum than in the more mesophytic habitat. The range of variation is also far greater in the Tucson than in the Cold Spring Harbor series.

In using cryoscopic methods we have so far failed to find pressures so high as those recorded by Fitting. We are not, however, ready to suggest that they do not occur. Possibly our failure to demonstrate them in the Tucson region may be due to the fact that our determinations were carried out at the close of the winter and spring rainy season, and hence on plants which had not been subjected to the maximum dryness of the region in question during the growing season of the year in which the determinations were made.

J. Arthur Harris,
John V. Lawrence,
Ross Aitken Gortner

On the Genus Trachodon[1]

In 1902 Mr. J. B. Hatcher published an article[2] entitled "The Genera and Species of the Trachodontidæ (Hadrosauridæ, Claosauridæ) Marsh," in which the conclusion was reached

> that the ten genera [of the Trachodontidæ] which have been proposed should be reduced to two. *Trachodon* Leidy and *Claosaurus* Marsh, while the remaining eight genera should be treated as synonyms of *Trachodon*, which should also be made to include *T.* (*Claosaurus*) *annectens* Marsh; while the smaller *Claosaurus agilis* described by Marsh from the Kansas chalks [Niobrara] may still be considered as pertaining to a distinct genus.''

These conclusions were almost unanimously adopted by American vertebrate paleontologists in their subsequent work, and this general use of the term *Trachodon* has continued up to the present time.

The finding of more perfect material in recent years has shown that several of the species formerly referred to *Trachodon* represent distinct genera, and in the light of these discoveries Hatcher's reduction now appears to have been too radical, but he was probably correct in restricting *Claosaurus* to the single species from the Niobrara formation.

It is unfortunate, however, that this view of the genus *Trachodon*, which includes species from the Judith River formation to the close of the Lance, has become so widely accepted by paleontologists.

In the first place the type of the genus (*Trachodon mirabilis* Leidy) is from the Judith River formation and was founded upon inadequate material consisting of "specimens of teeth generally very much worn and in a fragmentary condition," so that it is quite impossible to identify positively with them better and subsequently discovered specimens.

That later Hatcher[3] appreciated this fact is clearly shown by the following extract:

> Although the trachodonts are easily distinguishable by their teeth from the other Dinosauria of these beds [Judith River] it is scarcely possible to identify the various species of this genus or the genera of the family from the teeth alone.

Even though it eventually be found that

cooling, by the use of tables already published. See Harris and Gortner, *Amer. Jour. Bot.*, 1: 1914.

[1] Published with the permission of the Director of the U. S. Geological Survey.

[2] *Annals of the Carnegie Museum*, Vol. I., 1902, pp. 377–386.

[3] T. W. Stanton and J. B. Hatcher, ''Geology and Paleontology of the Judith River Beds,'' Bull. 257, U. S. Geol. Surv., 1905, pp. 96–97.

Trachodon can be placed on a sound footing, there is now reason for believing this genus is not present in the Lance formation, as indicated by the fewer number of teeth in all of the known specimens from the Judith River, Belly River and Two Medicine formations.

In the U. S. National Museum collections there are several complete dentaries of the Lance trachodonts in which the vertical rows of teeth vary from 52 to 57 in number. All of those in the collection from the other formations mentioned above have fewer rows, varying from 39 to 47. When it is known that each vertical row has from six to ten teeth, the difference in the total number is considerable.

The same condition prevails in the few maxillæ available. It thus seems that the earliest known trachodonts as in the more primitive Ceratopsians, have a smaller number of teeth, so that now it may be safely asserted that one of the marked phases in the specialization of the members of this group in successive geological periods is a progressive increase in the number of teeth in the dental magazines.

Since it is now known that the genus *Trachodon* is based upon specimens from the Judith River formation, and that all available trachodont material from that and equivalent formations shows a reduced dentition, this smaller number of teeth would in itself constitute a difference sufficient to restrict the genus *Trachodon* to species from the Judith River formation.

This difference I have no doubt will be augmented by other characters when sufficient material is obtained for comparison. I would therefore restrict the genus *Trachodon* to Judith River species.

This leaves the Lance trachodonts without generic designation, and it will on that account be necessary to revive one of the older generic terms, but I find that had been done before the appearance of Hatcher's article. In 1901[4] Lucas called attention to the identity of the type of *Thespesius occidentalis* Leidy with the homologous parts of *Claosaurus annectens* Marsh, and "that consequently this Dinosaur must be known by Leidy's name."

In 1902[5] Hay, upon the authority of Lucas, made *Claosaurus annectens* a synonym of *Thespesius occidentalis,* including under the same genus the Niobrara species *C. agilis,* but this proposed change in nomenclature has been entirely ignored by paleontologists in subsequent work.

I have recently compared the types of *Thespesius occidentalis* Leidy and *Claosaurus annectens* Marsh and can testify to the close similarity of the homologous bones. The inadequacy of the type material upon which *Thespesius* is based (two caudal centra and a proximal phalanx) is fully recognized, but that these pertain to a trachodont dinosaur there can be no doubt. It is now positively known from the geological mapping done in recent years, in the locality where this material was obtained, that the specimens came from the Lance formation on the Grand River in what is now the state of South Dakota. Despite the meagerness of the material upon which it is founded, it seems to me that *Thespesius,* being the older term, is the logical choice of names for the designation of the trachodont dinosaurs from the Lance formation.

While it can not be positively demonstrated that *occidentalis* and *annectens* are identical, it is equally true that they can not be shown to represent distinct species. Since the localities from which the type specimens came are not far apart geographically, it appears most probable, however, that they do represent one and the same species. I would therefore endorse the use of *Thespesius occidentalis* as first proposed by Lucas.

The chief points that I have attempted to bring out in the preceding lines may be summed up as follows:

1. That the trachodont dinosaurs of the Judith River and equivalent formations have fewer vertical rows of teeth in the jaws than those from the Lance.

2. That this feature constitutes a sufficient

[4] F. A. Lucas, "Paleontological Notes," SCIENCE (2), Vol. 12, 1900, p. 809.

[5] O. P. Hay, "Bibliography and Catalogue of the Fossil Vertebrates of North America," Bull. No. 179, U. S. Geol. Surv., 1901, pp. 502–503.

structural difference to separate generically all Judith River, Belly River and Two Medicine trachodonts from those obtained in the Lance formation, and that therefore the use of the term *Trachodon* should be restricted in its application to some one of those trachodonts found in the older beds.

3. That the restriction of the genus *Claosaurus* to the Niobrara species *C. agilis* Marsh first proposed by Hatcher be endorsed.

4. That *Claosaurus annectens* Marsh should be regarded as a synonym of *Thespesius occidentalis* Leidy as first proposed by Lucas.

CHARLES W. GILMORE
U. S. NATIONAL MUSEUM,
January, 1915

THE SOCIETY OF AMERICAN BACTERIOLOGISTS. II

Technique

Under the supervision of G. F. Ruediger

The Bacteriological Work of the Bureau of Chemistry and Its Possibilities: CHARLES THOM.

The papers presented by members of the bacteriological staff of the Bureau of Chemistry are fairly representative of the manner in which numerous problems arising from the enforcement of the Food and Drugs Act are being met by the bacteriological laboratory. Very many of the food products and other preparations met with in inspection work have not been adequately studied by bacteriologists. No analysis of the flora present in such substances is available. Standard methods for testing them have not been developed. The workers into whose hands they fall must then make a full study of several to many brands of the commercial article and very frequently follow the product every step of the way back to the actual producer before adequate data can be obtained to determine what action, if any, shall be taken by the bureau. The members of the Bacteriological Society are earnestly requested to aid this work whenever opportunity arises by studying the bacteriological conditions obtaining in food-stuffs and the standardization and publication of methods of procedure.

In addition to its inspection work, the bureau is now establishing a research laboratory to take up food deterioration, fermentation and technically bacteriological and mycological work upon unsolved problems concerning foods and drugs. This work will be carried in the closest possible cooperation with the chemical laboratories of the bureau dealing with the same related problems. By these two methods of attack it is hoped to enlarge our knowledge of the flora of food stuffs and the relation of these organisms to normal and abnormal conditions as found.

Methods of Counting Bacteria: ROBERT S. BREED.

Three methods of counting the number of bacteria present in various substances have been generally recognized. In order of their historical development, they are the microscopical method, the dilution method and the plating method. For the past few years, however, the latter method has been used, especially among American bacteriologists, almost to the exclusion of the others and this, in spite of the fact that what little comparative work has been done indicates that certain uncontrollable elements in this technique cause large errors.

Among other causes of irregularities in the counts, there are two which tend to lower the count in both the dilution and the plating method. One of these is the fact that the organisms present in the substance under examination may fail to grow in the culture medium used, and the other, that the clumping of the organisms reduces the number of centers from which growth occurs. The microscopical technique is free from these objections, but it is open to another in all cases where a count of living organisms only is desired. This objection arises because of the fact that it is ordinarily impossible to distinguish organisms which were alive at the time the preparation was made from those which were dead. This difficulty causes the count obtained in this way to be higher than it should be.

These conditions which have thus far proved to be uncontrollable in all of the three methods are largely responsible for the big discrepancies in the comparative counts which have been made. These discrepancies show most strikingly that all so-called bacterial counts are much better styled "estimates" than "counts." Statements that certain substances, such as milk, water, sewage and the like, contain such and such numbers of bacteria are particularly unfortunate, for they are plain misstatements of facts. In most cases the figures given represent counts of colonies on agar or gelatin and may be properly so recorded but these figures are usually far below the actual number of bacteria present.

So far as raw milk is concerned, microscopical methods of counting have been shown to have great usefulness, for, in these cases, the number of

dead bacteria present is at a minimum. Moreover, in those cases where they are present, they are just as indicative of the past history of the milk as are living bacteria. Very variable conditions in regard to the clumping of bacteria in milk have been observed. In many cases the bacteria occur largely as single individuals or as clumps of twos, in other cases the milk is filled with compact clumps which could not be separated by any known methods of plating. Where thick cream is present and the right types of bacteria occur, colonies may be formed much like those found on agar or gelatin. These variations in clumping produce very variable effects on the plate count which would be unrecognizable where this technique is used alone.

The Standard Method of Determining Nitrate Reduction: Robert S. Breed.

Attention is drawn to the fact, more or less generally known, that the Committee on Standard Methods of Bacterial Water Analysis have inadvertently given us two different formulæ for nitrate broth in each of the two editions of the Standard Methods which have been published. All of the formulæ call for one gram of peptone per liter, but the amount of nitrate varies. Altogether three different amounts are mentioned, namely, 2 grams, 0.2 gram and 0.02 gram per liter.

The committee's statement that the nitrate reduction test is sometimes quite erratic has been explained for some cases at least by tests which have been carried out at the New York State Experiment Station. Fifty cultures of bacilli of the colon group, isolated from a sewage-polluted stream, gave very erratic results with the standard broth which contained 0.2 gram of nitrate per liter, scarcely one third of the cultures giving results which showed a clear reduction. However, as soon as the amount of peptone was increased to five grams per liter, all of the cultures gave positive reactions for all tests.

On the other hand, tests for thirty cultures of bacilli of the *subtilis* group isolated from soil gave unmistakably positive or unmistakably negative results in a number of tests in the same nitrate broth. Varying the amount of peptone from one to five grams per liter had no influence on the results. Twenty of these cultures reduced nitrates, while ten failed to do so. In all cases there was a vigorous growth of the bacilli in every tube.

Tests with a single culture of an unknown soil organism showed, however, that it was necessary to be cautious in recommending that the amount of peptone in the standard broth be increased. This organism showed a condition the exact reverse of that just reported for the colon bacillus. Positive results were obtained in all cases where 1 gram of peptone per liter was used, while increasing the amount of peptone caused erratic and finally negative results when as much as 5 grams per liter was used.

Evidently nitrate reduction should be tested in a broth in which the organism to be tested will grow vigorously. Irregular results are open to suspicion in all cases. No one broth can be used for all organisms and suitable broths must be devised to fit each group of organisms. It is particularly unfortunate to report an organism as lacking the power to reduce nitrates when it fails to reduce them in a broth in which it does not grow. Either such results should not be reported at all or reported as doubtful.

Starch Agar, a New Culture Medium for the Gonococcus: Edward B. Vedder.

Starch agar is a beef-infusion agar (1.5 per cent.) without salt or peptone, to which is added 1.0 per cent. of starch, preferably corn-starch, though potato starch or tapioca will serve. Reaction, 0.2–0.5 acid to phenolphthalein. The advantages of this medium are as follows:

1. The gonococcus grows very freely on this medium, producing a heavy growth suitable for the preparation of vaccines or antigens.

2. When the tubes are sealed with paraffine, cultures remain alive upon this medium for a long time, at least 20 days, so that transfers of stock cultures may be safely made every two weeks instead of every three or four days, as is customary when other media are used.

3. This medium may be melted and used in pour plates in order to isolate gonococci in pure culture from gonorrheal pus.

4. Some other organisms that are usually cultivated with considerable difficulty grow well on this medium; *i. e.*, certain strains of tubercle bacilli, the lepra bacillus (Duval), and freshly isolated streptococci and pneumococci.

5. The medium is suitable for routine use as practically all organisms grow as well or better on this medium as on plain agar.

The great simplicity of preparation of this medium and its many advantages appear to indicate that it may be very useful to many workers.

A New and Rapid Method for the Isolation and Cultivation of Tubercle Bacilli Directly from the Sputum and Feces, with the Aid of Sodium Hydrate and Gentian Violet-egg-meat Juice Media: S. A. Petroff.

The object of this investigation was to devise a simple, practical and reliable method for the isolation and cultivation of the tubercle bacillus from the sputum and feces. Most of the methods employed in the last twenty years do not give uniformly positive results.

Taking into consideration the inhibitory action of gentian violet on many organisms, it was selected as the most favorable stain.

Preparation of the Media

I. *Meat Juice.*—Five hundred grams of beef or veal are infused in 500 c.c. of a 15-per-cent. solution of glycerine in water. Twenty-four hours later the meat is squeezed in a sterile meat press and collected in a sterile beaker.

II. *Eggs.*—Sterilize the shells of the eggs by immersing for ten minutes in 70 per cent. alcohol. Break the eggs into a sterile beaker, mix well and filter through sterile gauze. Add one part by volume of meat juice.

III. *Gentian Violet.*—Add sufficient 1 per cent. alcoholic gentian violet to make a dilution of 1 to 10,000.

Place in sterile test tubes and inspissate for three successive days. First day at 85° C. until all the medium is solidified. On the second and third days not more than one hour at 75° C.

Method of Isolating Tubercle Bacilli from Sputum

The use of fresh sputum is advisable. A mixture of the sputum and a 3-per-cent. sodium hydrate solution are left in the incubator for 20–30 minutes, then neutralized to sterile litmus paper with normal hydrochloric acid, centrifugalized and the sediment inoculated into the tubed media.

Method of Isolating Tubercle Bacilli from the Feces

The isolation of tubercle bacilli from the feces is not an easy problem. The concentration of the sodium hydrate is not as important as the length of exposure. The solid food particles are removed from the feces by dilution with water and filtration through gauze.

The filtrate is saturated with sodium chloride and at the end of half an hour all the bacteria will be found floating in a fine film. This film is collected and normal sodium hydrate added, shaken well and incubated at 37° C. for 3 hours. Then neutralized as is sputum, centrifugalized and sediment inoculated.

The method presented has proven very simple and accurate for the isolation of tubercle bacilli from the sputum. The partial success in isolating and cultivating tubercle bacilli from the feces may be due to the fact that many of the bacilli are possibly dead.

Comparative Analysis of Several Peptones: R. C. COLWELL.

An investigation of the comparative merits of four brands of peptone is being made to determine the advisability of substituting an American brand for Witte's in Standard Methods of Bacteriological Analysis. The following table embodies the results of the chemical analysis.

	Total Nitrogen %	Ash %	Moisture %	Fermentation of Peptone Broth	Presence of Sugar	Acidity of 1% Peptone Broth
Witte's "Peptonum Siccum" .	14.92	2.09	4.97	0	0	0.40
Digestive Ferments Co. "Peptone Powder Bacteriological"	15.83	4.18	2.96	0	0	0.24
Armour & Co. "Peptone Powdered containing 10% lactose"	13.67	5.76	4.09	+	[4]	0.60
Bausch & Lomb "Peptone from meat, dry"	12.82	4.32	6.06	+	[4]	0.56

The tests made upon the peptones to determine their relative reliability in the making of culture media has not yet covered long enough time to warrant any definite conclusions. However, it may be said that those peptones containing lactose seem to be inferior to those which are free from lactose.

A New Method of Precipitating Cellulose for Cellulose Agar: F. M. SCALES.

The method of precipitating cellulose to be used for the preparation of cellulose agar is as follows: 100 c.c. of concentrated sulphuric acid are diluted with 60 c.c. of distilled water in a two-liter Erlenmeyer flask. The diluted acid should be cooled to about 60° to 65° C. Moisten with water five grams of filter paper, which are sufficient for one liter of cellulose agar, and add it to the acid, which should be vigorously agitated until the cellulose is dissolved. The flask is then filled as quicky as possible with cold tap water. The process of dissolving the paper and filling the flask requires about one minute. The precipitate may now be thrown on a filter and washed with distilled

[4] Lactose, about 10 per cent.

water until the filtrate no longer gives a test for sulphuric acid. As the volume of the suspension finally drains down to about 200 c.c. any deposit of cellulose on the filter may be removed with a camel's-hair brush. A hole is then punched in the bottom of the filter and the whole precipitate washed out and made up to 500 c.c., when it may be added to 500 c.c. of 1-per-cent. agar containing the nutrient salts. Cellulose-destroying bacteria were plated on a medium containing cellulose precipitated by this method and on one containing cellulose from Schweitzer solution. The destruction of the cellulose was about the same in both media.

New Technique for Studying Halophytic Organisms: K. F. Kellerman and N. R. Smith.

1. For staining flagella from salt media the bacteria are placed in a salt water suspension, killed by addition of 10 per cent. formalin, then placed in collodion dialyzing tubes and the soluble salts removed by dialysis. The bacteria are thrown down by centrifuging, and the residue spread on clean slides and stained by any method desired.

2. For isolating bacteria injured by heating to 42° C., use silica jelly. This can not be mixed with beef broth or peptone. When these nutrients are desired, pour sterile Petri plates of beef agar or peptone agar, allow them to harden for twenty-four hours, then for the isolating medium use synthetic salt solution and silicic acid solution, and pour this rapidly over the sterile beef or peptone agar plates and allow to remain perfectly quiet. The silica jelly forms a layer over the agar layer and the nutrients mix by diffusion.

3. Use collodion sacs to maintain constant supply of slightly soluble salts in clear solutions in bacterial culture flasks.

The Relative Merits of the Bubbling Method of Enumerating Air Bacteria: John J. Wenner.

The writer is making a study of the modified Petri sand filter and the Rettger aeroscope bubbling filter for the purpose of determining their relative degree of efficiency, simplicity and practical value. The sand filter was, at first, set up as described in a previous paper by Weinzirl and Thomas ('12). As this apparatus was very cumbersome, it was soon modified by discarding one stopper entirely, holding the sand in the tube by means of a tight wire gauze, and attaching the aspirating tube directly to the main filtering tube. The great weakness of the sand filter is in the transference of the organisms caught in the sand, to the plate, so as to be easily and accurately counted. This was done in three ways: (1) The sand was distributed among several sterile plates and gelatin added. (2) The sand was transferred to a small sterile flask holding 10 c.c. of salt solution and an aliquot part plated. (3) The sand was transferred to a sterile test-tube holding 5 c.c. of salt solution, thoroughly washed, and the liquid plated with an equal amount of strong gelatin. This last method appears to be the most practical.

The Rettger aeroscope was used as originally described by Rettger ('10). A second plate, from washing the aeroscope and test-tube, should, in all cases, be poured.

The two filters were run simultaneously and consecutively under similar conditions. Air was taken in a dusty attic room and from a specially prepared box.

Both methods are equally simple and both filter with a high degree of accuracy. In plate pouring the aeroscope is simpler and contamination is not so easy. Besides the bubbling method is visible and audible, which may at times be very desirable. The writer's work has not been completed, but from his results thus far obtained the bubbling method gives him an excess in the number of colonies, over the sand filter. As technique is very delicate, a large number of tests have to be made for the results to be of any value.

One of the great drawbacks in the practical use of the air filter is the inconvenience of the aspirator. We need an aspirator that is easily transferred from place to place, one that is simple and yet will give a fair degree of accuracy, as well as a uniform and continuous rate of flow. For this purpose the writer has been experimenting by placing two movable tanks in a wooden box. The tanks are connected with a rubber tube while another tube from each tank extends to the outside. The filter is attached to the proper tube and the water passed from one tank to the other.

Suggestions for Partial Anaerobic Cultures: Ward Giltner.

Anaerobiosis and aerobiosis are relative terms. The oxygen requirements and tolerance of microorganisms present a gradation from practically an absence of oxygen pressure to many times atmospheric pressure. The lowering of oxygen tension by biological means, Nowak's *B. subtilis* cultures, was introduced in connection with the growth of *Bact. abortus,* an organism requiring a slightly lower oxygen pressure than atmospheric. In this method the oxygen-consuming culture and *Bact. abortus* are usually grown in vitro separately, the two cultures being placed in a Novy or similar sealed jar. A simpler method is desirable. Re-

cently Geo. D. Horton[5] has proposed to grow both organisms on adjacent agar slants separated by a glass slide in the same test tube.

We suggest the following special tubes in which the culture surfaces may be kept separate while the air chamber is continuous or freely communicating between the sides. U tube with perforated corks and U capillary tube U and H tube. Probably the H tube will prove the most satisfactory. The communicating cross tube should be as short as possible so that the double tube may be held in the hand as conveniently as an ordinary test tube. Different media may be used on either side, either solid or liquid or a medium one side and some chemical on the other. The tubes should be plugged with rubber stoppers or sealed with paraffin or wax.

DR. A. PARKER HITCHENS,
Secretary

(*To be continued*)

SOCIETIES AND ACADEMIES

THE BIOLOGICAL SOCIETY OF WASHINGTON

THE 538th meeting of the society was held in the Assembly Hall of the Cosmos Club, Saturday, March 20, 1915, called to order by President Bartsch at 8 P.M., with 45 persons present.

Under heading Brief Notes, General Wilcox called attention to a Cedar of Lebanon near Jackson's statue in Lafayette Square.

The first paper of the regular program was by T. S. Palmer, "Notes on the Importation of Foreign Birds." The speaker discussed the subject with special reference to canaries, parrots and game birds. He stated that about 500 permits for importation of birds are issued annually by the Department of Agriculture, the number of birds imported a year amounts to about half a million; as high as 17,000 birds have arrived in a single day; the number of species imported is about 1,500; canaries constitute by far the largest number brought in. Methods of breeding birds, caring for them in transit, selecting and teaching singers and talkers were explained. Dangers of importing contagious diseases as the "quail disease" and methods of quarantining were pointed out. The effect of the European war on the importation of birds was commented upon. Dr. Palmer's paper was discussed by the chair, Dr. Stiles and Mr. Goldman.

The second paper was by Ned Dearborn, "Notes on the Breeding of Minks in Captivity." Among the habits of the mink attention was called to their profound diurnal sleep, cries emitted, polygamous nature, and cat-like character of food. The speaker stated that the period of gestation was found to be 42 days, number of young at birth 1 to 8; eyes of young remain closed for one month after birth; young may be weaned at 6 weeks; minks breed when a year old; and their fur is suitable for market at a year and a half, experiments showed that different types of diet had no effect on quality of fur. Speaker concluded that breeding of minks for commercial purposes was possible. Dr. Dearborn's paper was discussed by Messrs. Wetmore, A. B. Baker and Cooke.

The third and last paper was by M. W. Lyon, Jr., "*Endamœba gingivalis* and Pyorrhea." The speaker discussed the cause of pyorrhea or Rigg's disease, the *Endamœba gingivalis*, recently discovered by Dr. Allen J. Smith and others. He called attention to the pathologic lesions produced by the Endamœba and by the various bacteria associated with it; mentioned the amœbicidal action of emetin hydrochlorid administered systemically or locally; and reviewed some of the early references to the Endamœba before it was considered the cause of pyorrhea. The paper was illustrated by lantern slides of Gros's original drawing of the organism, and of several photomicrographs and drawings of living and stained Endamœbas, bacilli and spirochetes from a case of pyorrhea. Dr. Lyon's paper was discussed by Dr. Stiles and Mr. Goldman.

M. W. LYON, JR.,
Recording Secretary

WASHINGTON, D. C.

THE NEW ORLEANS ACADEMY OF SCIENCES

THE annual meeting of the academy was held on Wednesday, March 10, in Stanley Thomas Hall, Tulane University. The following officers were elected for the coming year: President, Dr. Gustav Mann; First Vice-president, Dr. R. B. Bean; Second Vice-president, Dr. W. O. Scroggs; Treasurer, Mrs. E. J. Northrup; Librarian, Professor H. F. Rugan; Secretary, R. S. Cocks. The paper of the evening was read by Dr. C. W. Duval on "Modern Conceptions which Tend to Explain the Occurrence of Secondary Infection in Typhoid Fever and Tuberculosis." There was considerable discussion of the paper in which Drs. Mann, Lemann, Friedrichs participated. At the close of the meeting refreshments were served and the Academy adjourned.

R. S. COCKS,
Secretary

[5] *Jour. Inf. Dis.*, Vol. 15, No. 1, July, 1914.